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EXAMINING THE ROLE OF DECISION BIASES IN SHAPING ACQUISITION DECISIONS WITHIN DEFENSE ACQUISITION PROGRAMS

Kiesling, James K.; Chong, Diane M.

Monterey, CA; Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

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by

James K. Kiesling and Diane M. Chong

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Thesis Advisor: Deborah E. Gibbons
Second Reader: Raymond D. Jones

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Our research questions the assumption of human rationality underlying the Government Accountability Office's (GAO) working theory that systemic incentives motivate defense acquisition participants to deviate from sound acquisition practices (incentives narrative) and explores whether systematic and predictable mental errors (cognitive biases) may also have a significant causal influence. We assessed the conclusiveness of GAO's incentives narrative and examined whether it is likely that cognitive biases significantly contribute to deviations from sound acquisition practices. First, we compiled a decision bias dictionary (DBD) of cognitive and motivational biases. Then, we evaluated a selection of case studies and used the DBD to assign one or more bias codes for passages indicating deviations from sound acquisition practices or situations/decisions that were likely susceptible to one or more decision biases. Our analysis identified 347 discrete instances in which a decision bias was evident, including a significant number of both cognitive and motivational biases. We also found that although GAO's incentives narrative was not represented as the singular correct view when it was initially proposed over 25 years ago, it has remained largely unchanged and unquestioned. Therefore, to improve the implementation of sound acquisition practices and ultimately improve acquisition outcomes, acquisition reform efforts must research and address both categories of decision biases.

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James K. Kiesling
Civilian, Department of the Army
BSBA, University of Central Florida, 2009

Diane M. Chong
Civilian, Department of the Air Force
BA, Capital University, 1993

Submitted in partial fulfillment of the
requirements for the degree of

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NAVAL POSTGRADUATE SCHOOL
June 2020

Approved by: Deborah E. Gibbons
Advisor

Raymond D. Jones
Second Reader

Brett M. Schwartz
Academic Associate, Graduate School of Defense Management

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ABSTRACT

Our research questions the assumption of human rationality underlying the Government Accountability Office's (GAO) working theory that systemic incentives motivate defense acquisition participants to deviate from sound acquisition practices (incentives narrative) and explores whether systematic and predictable mental errors (cognitive biases) may also have a significant causal influence. We assessed the conclusiveness of GAO's incentives narrative and examined whether it is likely that cognitive biases significantly contribute to deviations from sound acquisition practices. First, we compiled a decision bias dictionary (DBD) of cognitive and motivational biases. Then, we evaluated a selection of case studies and used the DBD to assign one or more bias codes for passages indicating deviations from sound acquisition practices or situations/decisions that were likely susceptible to one or more decision biases. Our analysis identified 347 discrete instances in which a decision bias was evident, including a significant number of both cognitive and motivational biases. We also found that although GAO's incentives narrative was not represented as the singular correct view when it was initially proposed over 25 years ago, it has remained largely unchanged and unquestioned. Therefore, to improve the implementation of sound acquisition practices and ultimately improve acquisition outcomes, acquisition reform efforts must research and address both categories of decision biases.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAG	Advanced Arresting Gear
AAV	Assault Amphibious Vehicle
ACV	Amphibious Combat Vehicle
CAPE	Office of Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Description
CoP	Community of Practice
DAS	Defense Acquisition System
DBD	Decision Bias Dictionary
DOD	Department of Defense
DBR	Dual Band Radar
EFV	Expeditionary Fighting Vehicle
EMALS	Electromagnetic Aircraft Launch System
GAO	Government Accountability Office (after 2004) or Government Accounting Office (prior to, and including 2004)
HBP	Heuristics and Biases Paradigm
KBA	Knowledge-Based Acquisition
JSF	Joint Strike Fighter
LCS	Littoral Combat Ship
MDA	Milestone Decision Authority
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
MDAP	Major Defense Acquisition Program
MRL	Manufacturing Readiness Level
NAVSEA 05C	Naval Sea Systems Command Cost Engineering and Industrial Analysis Group
NCCA	Naval Center for Cost Analysis
PgM	Program Manager
RCM	Rational-Choice Model

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I. INTRODUCTION

> We all know what needs to be done. The question is why aren't we doing it?
>
> —David Packard
> (Government Accountability Office [GAO], 2015d, p. 4)

> The least questioned assumptions are often the most questionable.
>
> —Paul Broca (Schiller, 1992)

> We have gaping blind spots far bigger than our intuition would suggest.
>
> —Kyle Eschen, (Eschen, 2016)

Are you a rational decision maker? We all would like to believe we are. However, significant advancements in decision science theory since the 1955, including the works of three Nobel Laureates, have been described as a slow steady retreat from the assumption of rationality in human decision making. In fact, there is now a vast, expanding, and robust body of knowledge and experimental evidence that points to the prevalence of systematic mental errors (a.k.a. cognitive biases) in decision making. Intelligent and reasonable test subjects, even experts in their own field of expertise, are susceptible to cognitive biases. In his Nobel Prize lecture, Kahneman recalled his earliest findings in the field of decision research: "Remarkably, the intuitive judgments of these experts did not conform to statistical principles with which they were thoroughly familiar" (2002, p. 450; Tversky & Kahneman, 1971). The systematic discrepancies between how people actually behave (descriptive models) versus how they theoretically should behave (prescriptive models [a.k.a. normative models]) have given rise to the relatively new and disruptive study of behavioral economics.

In a thorough review of Department of Defense (DOD) acquisition reform efforts from 1960–2009, Fox (2009) found that all of the 27 major defense acquisition studies during this time period "arrived at most of the same findings and made similar recommendations

[for reform]" (p. xi). In his report's conclusion, Fox (2009) referenced and echoed the findings of an influential 1992 GAO report, stating "it is clear that the incentives inherent in the acquisition culture offer an explanation as to why weapon acquisition problems persist despite numerous attempts at reform" (p. 191; GAO, 1992). This conclusion encapsulates what we refer to as GAO's incentives narrative, and it has become a foundational assumption underlying GAO's recommendations for acquisition reform. Fundamentally, our research questions the validity of entrenched assumptions of human rationality underlying GAO's incentives narrative; and offers an alternative narrative that reconciles these assumptions with recent developments in decision science theory. We contend that deviations from sound acquisition practices are likely the result of a combination of incentive-driven and cognitive-driven decision biases. Even if DOD acquisition reform efforts were finally able to eliminate all of the systemic and intractable incentives identified by GAO, we argue this would not eliminate or mitigate the likely influence of cognitive-driven decision biases. Therefore, acquisition reform efforts must address both categories of decision biases to improve acquisition outcomes.

This chapter provides necessary context regarding the focus of this research. First, a common terminology is established to ensure a consistent application among the varying fields of study incorporated into this research. Next, we provide necessary background beginning with a summary GAO's findings concerning DOD weapon systems acquisition, a description of what we refer to as GAO's incentives narrative, and overview GAO's recommended knowledge-based acquisition (KBA) approach. We conclude the background section with a discussion of how the assumption of rationality of human decision making is a pivotal theme within our research. Next, the problem is defined in broad terms, followed by more detailed research objectives and specific research questions. Then, the purpose and methodology of our research is detailed; followed by a discussion of the assumptions, scope, and limitations relating to this research project. Finally, a thesis statement provides a summary of the problem, and takes a position regarding the conclusions to be drawn from this research.

A. TERMINOLOGY

The terminology used within our research aligns most with behavioral decision research, to include the relatively new field of behavioral economics. However, because classical/behavioral psychology, classical/behavioral economics, organizational behavior, sociology, etc., study many of the same human behaviors using differing terminologies and definitions, we specify the meaning of several terms used in this paper.

1. Biases

In 2011, Kahneman states "systematic errors are known as biases, and they recur predictably in particular circumstances" (p. 3).

2. Heuristics

A heuristic is a simple mental process that "helps find adequate, though often imperfect, answers to difficult questions" (Kahneman, 2011, p. 98). According to Tversky and Kahneman (1974), we all rely on heuristics every day to "reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations" (p. 1124). A heuristic is not inherently good or bad, and while they are mostly characterized as automatic and intuitive, their use can also be deliberate. (Kahneman & Frederick, 2002) Simply, heuristics are mental shortcuts or rules of thumb we all use continuously to make decisions and/or register impressions quickly, economically, and under uncertainty. Admittedly, this is an oversimplification of heuristics, and a more nuanced and technical description of heuristics is discussed in greater detail in our literature review. Finally, Kahneman and Frederick (2002) stated that while they developed the theory of heuristics while studying judgement under uncertainty, "the restriction to particular heuristics and to a specific context is largely arbitrary" (p. 4). For instance, they explained how heuristics are used when subconsciously perceiving visual information such as size, dimension, and distance. (Kahneman & Frederick, 2002; see also Tversky & Kahneman, 1974; Kahneman, 2002, 2003) For the purposes of this paper, the term "heuristics" is used to reference judgmental heuristics, and the terms "cognitive bias," "cognitive-driven bias," and "cognitive decision bias" may be used interchangeably to include heuristic-driven biases.

3. Cognitive Biases

Montibeller and von Winterfeldt (2015) define a cognitive bias as a "systematic discrepancy between the 'correct' answer in a judgmental task, given by a formal normative rule, and the decisionmaker's or expert's actual answer to such a task" (p. 1231). Cognitive biases are consistent and predictable "mental errors caused by our simplified information processing strategies" (Heuer, 1999, p. 111). Cognitive biases are typically distinguished from cultural, organizational, and motivational biases (Heuer, 1999). In addition, Arnott (2006) states that "factors that influence decisions arising from psychological pathology, religious belief or social pressure (including customs, tradition and hero worship)" (p. 59, 62), are "normally excluded from consideration in cognitive bias research" (p. 59). Biases related to judgement have been called cognitive biases, decision biases, or judgmental biases. Finally, some widely accepted cognitive biases—overconfidence bias being the foremost—may or may not be the result of a combination of mental errors and motivational factors. Therefore, although these biases are widely categorized as cognitive biases, our research highlights these unique biases in our research. Unless otherwise specified, in the context of our studies, a cognitive bias is a mental error, and the terms "cognitive bias," "cognitive-driven bias," and "cognitive decision bias" may be used interchangeably to encompass these types of biases.

The body of knowledge relating to cognitive biases is vast and expanding, supported by scientifically robust and repeatable experimental evidence, and is widely considered to be generalizable to a broad range of fields of study (Heuer, 1999; see also Arnott, 1998, p. 3). Korteling et al. (2018) describes cognitive biases as "systematic, persistent, and consistent over different people and conditions" (p. 2). Although knowledge of cognitive biases cannot predict how any single individual will think or act in a particular situation, one can predict that a cognitive bias "will exist to a greater or lesser degree in most judgments made by most of the group" (Heuer, 1999, p. 113; see also Arnott, 1998, p. 3). Even experts are not immune from cognitive biases for which they are uniquely suited to resist. Heuer highlights that most "test subjects were experts in their field. They were physicians, stock market analysts, horserace handicappers, chess masters, research directors, and professional psychologists" (1999, p. 113; see also Kahneman, 2011; Davis, 2005; Tversky & Kahneman, 1974).

4. Motivational Biases

Montibeller and von Winterfeldt (2015) define motivational biases as "those in which judgments are influenced by the desirability or undesirability of events, consequences, outcomes, or choices" (p. 1231), further clarifying these can be conscious or subconscious. Motivational biases are also known as "incentive-driven biases" and "interest biases." Using the term "interest biases," Lovallo and Sibony define motivational biases as biases that "arise in the presence of conflicting incentives, including nonmonetary and even purely emotional ones" (p. 15). Tversky and Kahneman (1974) describe these biases as "motivational effects such as wishful thinking or the distortion of judgments by payoffs and penalties" (p. 1131). Unlike cognitive biases, motivational biases "result from one's own self-interest [and] any emotional or intellectual predisposition toward a certain judgment" (Heuer, 1999, p. 111). For the purposes of this paper, the terms "motivational bias," "incentive-driven bias," and "motivational decision bias" may be used interchangeably to encompass these types of biases.

5. Logical Fallacies

Fallacies are "common errors in reasoning that will undermine the logic of your argument. … [and] can be either illegitimate arguments or irrelevant points, and are often identified because they lack evidence that supports their claim" (Purdue Writing Lab, n.d.). Lt Col. Parry (2013) aptly describes the difference between logical fallacies and biases stating "Biases tilt our thinking in one direction or another. Fallacious logic doesn't just tilt one's thinking—it completely undermines it" (p. 49). While, logical fallacies are distinct from cognitive biases, many taxonomies of cognitive biases do not make this distinction, often including logical fallacies under general groupings of cognitive biases. Nonetheless, this distinction was not a substantive or practical issue for our research. The following are instances where we use the term "cognitive bias" instead of "fallacy" in order to maintain consistency with our primary source taxonomy of cognitive biases (Arnott, 1998, 2006). Arnott (1998) lists the terms "gamblers fallacy" and "conjunction fallacy" as cognates (i.e., similar terms) for what he describes as the "Chance" and "Subset" cognitive biases,

respectively. Lastly, Kahneman (2011) uses a similar term "planning fallacy" to describe what Arnott defines as the "Overconfidence" cognitive bias.

6. Decision Biases

Due to the multitude of terms used in this study, we have used the term "decision bias" to indicate a bias (cognitive, motivational, or some combination of the two), fallacy, or group/organizational dynamic which create predictable errors in judgement. Such an overarching term is necessary because not all biases can be neatly separated into discrete categories and are likely to overlap (Arnott, 2006, p. 59).

7. Incentives

For clarity and brevity, we must establish what is meant when discussing incentives, in the context of GAO's incentives narrative, because GAO's descriptions of incentives can be confusing, ambiguous, and/or inconsistent. Therefore, regardless of how the effect is achieved (i.e., negative reinforcement, positive reinforcement, punishment, etc.), we refer to incentives that promote unbiased knowledge-based and/or data-driven decisions as "positive incentives." Conversely, we refer to incentives that promote decisions based on individual or programmatic self-interest as "negative incentives." For instance, GAO (1992) states "decisions that restrict or control programs operate under weak incentives" (p. 38). We would simplistically interpret this statement to mean that decisions to restrict or control programs have weak positive incentives. In another example, GAO (1992) states "Such decisions [to improve a program's cost realism] face strong disincentives because they conflict with the other, more powerful, needs served by the programs" (p. 39). We would simplistically interpret this statement to mean that the decisions to improve a program's cost realism have strong negative incentives. When GAO uses the term "incentives" ambiguously or inconsistently, we either summarize their statements or directly quote GAO to include enough context and/or notes to indicate whether positive and/or negative incentives are indicated.

8. Rationality

The term "rational" is generally understood in common speech to indicate that someone is reasonable, but we specifically define this term here because "rationality" has a specific meaning in the context of our research. According to Kahneman (2011):

> For economists and decision theorists, the adjective has an altogether different meaning. The only test of rationality is not whether a person's beliefs and preferences are reasonable, but whether they are internally consistent. … Rationality is logical coherence—reasonable or not. (p. 411)

Throughout much of decision science research and within this paper, we use the word "irrational" to indicate a deviation for logical coherence, not a deviation from reason.

B. BACKGROUND

1. GAO's Findings Concerning Department of Defense Weapon Systems Acquisition

In their 2019 High-Risk Report, GAO (2019) once again identified DOD weapon systems acquisition as a high risk area. In fact, the report noted that DOD weapon systems acquisition has been on GAO's High-Risk List since 1990. Echoing their previous reports, they found that despite a long history of acquisition reforms, "many DOD programs continue to fall short of cost, schedule, and performance goals. Consequently, DOD often pays more than anticipated, buys less than expected, and, in some cases, delivers fewer capabilities to the warfighter" (GAO, 2019, p. 143). These persistent problems pose a significant risk to the United States. The timely delivery of affordable, high-quality products and weapon systems is essential to equipping our nation's warfighters; and is essential for the DOD to maintain technical superiority and overmatch over our adversaries, respond to rapidly evolving threats, and better protect and enable the warfighter (GAO, 2015d, pp. 1–2). In a familiar refrain from their prior reports, GAO (2017c) recommended Congress address a defense acquisition culture afflicted by "a prevailing set of incentives that encourages decisions to go forward with programs before they are ready, and a willingness to accept cost growth and schedule delays as the likely byproduct of such decisions" (GAO, 2017c, p. 273). GAO's assessment of defense acquisition, and their recommendations for congressional action are largely shaped by longstanding fundamental assumptions regarding the causal relationship between

incentives and deviations from sound acquisition practices, which according to GAO, ultimately lead to poor acquisition outcomes. In other words, GAO believes poor acquisition outcomes are partially the result of various incentives that favor optimistic perspectives that compromise good judgment when making decisions. For brevity, we refer to this causal relationship as the "incentives narrative." This paper seeks neither to confirm nor refute this narrative, but examines the narrative's fundamental assumptions and implications, and explores the possibility that cognitive biases may also have a causal influence that results in deviations from sound acquisition practices.

2. GAO's Incentives Narrative

This section provides an overview of GAO's conclusions regarding the connection between defense acquisition culture and incentives, and poor acquisition outcomes. GAO has reported on DOD acquisition programs since 1970 (GAO, 2009). The influence of GAO's findings and recommendations to Congress regarding proposed acquisition reform efforts for almost 50 years cannot be overstated. This section describes GAO's findings that the incentives narrative is the predominant underlying force which effectively undermines decades of acquisition reforms and established best practices.

GAO (1992) suggests that poor acquisition outcomes are the logical consequences of an acquisition culture, conflicted by various incentives, which constrains the implementation of sound acquisition practices. GAO has repeatedly found that already established best practices and policies are not being fully implemented. (GAO, 1992, p. 51; 2013, p. 1; 2014, pp. 6–8; 2015d, pp. 3–7; and GAO, 2019, p. 144) GAO (1992) defined "culture" in the context of the incentives narrative as the "collective patterns of behavior exhibited by the numerous participants in the acquisition process and the incentives for that behavior" (p. 2). According to GAO, this culture causes participants from the top-down to make suboptimal or even poor decisions. GAO (2015c) states "this culture is held in place by a set of incentives that are more powerful than policies to follow best practices" (p. 2). Furthermore, GAO (1992) states that DOD weapon system acquisitions "have become integral to policy decisions, definitions of roles and functions, justifications of budget levels and shares, service reputations, influence of oversight organizations, defense spending in localities, the industrial

base, and to individual careers" (p. 38). While reporting on poor acquisition outcomes for the Ford Class Aircraft Carrier Program, GAO (2015c) elaborates how incentives encourage deviations from sound acquisition practices:

> Competition with other programs vying for funding puts pressure on program sponsors to project unprecedented levels of performance (often by counting on unproven technologies) while promising low cost and short schedules. These incentives … create a culture in weapon system acquisition that encourages undue optimism about program risks and costs. … To be sure, this is not to suggest that the acquisition process is foiled by bad actors. Rather, program sponsors and other participants act rationally within the system to achieve goals they believe in. Competitive pressures for funding simply favor optimism in setting cost, schedule, technical, and other estimates. (GAO, 2015c, p. 13)

The report further elaborates:

> The experiences of the Ford-class program are not unique—rather, they represent a typical acquisition outcome. It is too simplistic to look at the program as a product of a broken acquisition process; rather it is indicative of a process that is in equilibrium. It has worked this way for decades with similar outcomes: weapon systems that are the best in the world, but cost significantly more, take longer, and perform less than advertised. The rules and policies are clear about what to do, but other incentives force compromises of good judgment. The persistence of undesirable outcomes such as cost growth and schedule delays suggests that these are consequences that participants in the process have been willing to accept. It is not broken in the sense that it is rational; that is, program sponsors must promise more for less in order to win funding approval. This naturally leads to an unexecutable business case. Once funded and approved, reality sets in and the program must then offer less for more. (GAO, 2015c, p. 15)

In summary, GAO believes poor acquisition outcomes are partially the result of an acquisition culture that is compromised by various incentives that favor optimistic perspectives that hinder good judgment when making decisions.

3. Knowledge-Based Acquisition (KBA) Approach

In order to address persistent cost, schedule, and performance issues within DOD weapons acquisition programs, GAO has consistently recommended DOD implement a knowledge-based acquisition (KBA) approach when making acquisition decisions. GAO (2004) indicates that in order to address these issues "it is essential that sound foundations

for investments in systems be laid now so that the resulting programs can be executed within estimates of available resources" (p. 2). The report also found the KBA approach to be the key to commercial firms' success developing "increasingly sophisticated products in less time and at lower cost" (GAO, 2004, p. 2). According to GAO (2005b), the KBA approach "enables developers to be reasonably certain, at critical junctures or 'knowledge points' in the acquisition life cycle, that their products are more likely to meet established cost, schedule, and performance baselines and, therefore provides them with information needed to make sound investment decisions" (GAO, 2005b, pp. 9–10). Fundamentally, a KBA approach seeks to base acquisition decisions upon knowledge and data. Because this methodology is widely considered to be a sound acquisition practice, we adopted the KBA approach as the primary normative standard for identifying deviations from sound acquisition practices in our analysis.

GAO considers the successful implementation of the KBA approach to be significantly influenced by incentives. In their report on the KBA approach, GAO (2004) incorporates elements of GAO's incentives narrative, stipulating that the successful implementation of the KBA approach was contingent upon DOD's ability to "instill incentives that encourage realism and candor in the acquisition process and sustain its commitment to improving business practices" (GAO, 2004, p. 9). DOD has formally adopted the KBA approach within DOD Directive (DODD) 5000.01 and DODD 5000.02 (Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics [OUSD{AT&L}], 2007, p. 7; OUSD(AT&L), 2003, pp. 2–3). Why, then, are DOD programs laden with cost, schedule and performance issues? Year after year, GAO has consistently found "DOD programs continue to not fully implement knowledge-based acquisition practices" (GAO, 2018a, p. 3; see also GAO, 2015a, 2016a, 2017a, 2019). In their most recent annual weapons systems assessment GAO (2019) found that, 45 out of 51 current programs reviewed failed to follow KBA practices and "proceeded into system development, through critical design reviews, and into production without completing the key knowledge-based practices … this lack of knowledge and the effects it can have throughout a program's acquisition life cycle can increase the risk of undesirable cost and schedule outcomes" (p. 3). GAO and DOD have consistently used the incentives narrative to explain acquisition

decisions that deviate from sound acquisition practices such as the KBA approach (GAO, 2017a). The constant refrain from GAO is that DOD needs to address incentives which encourage deviations from their recommended best practices. GAO (2017c) emphasizes this stating: "At this point, DOD needs to build on existing reforms—not necessarily revisiting the process itself but augmenting it by tackling incentives" (p. 272). If GAO's assessment regarding incentives—which they have repeated for over 25 years (GAO, 1992)—is correct, it would seem the status quo will not be changing anytime soon. Figure 1 illustrates the DOD acquisition process and GAO-identified knowledge points.

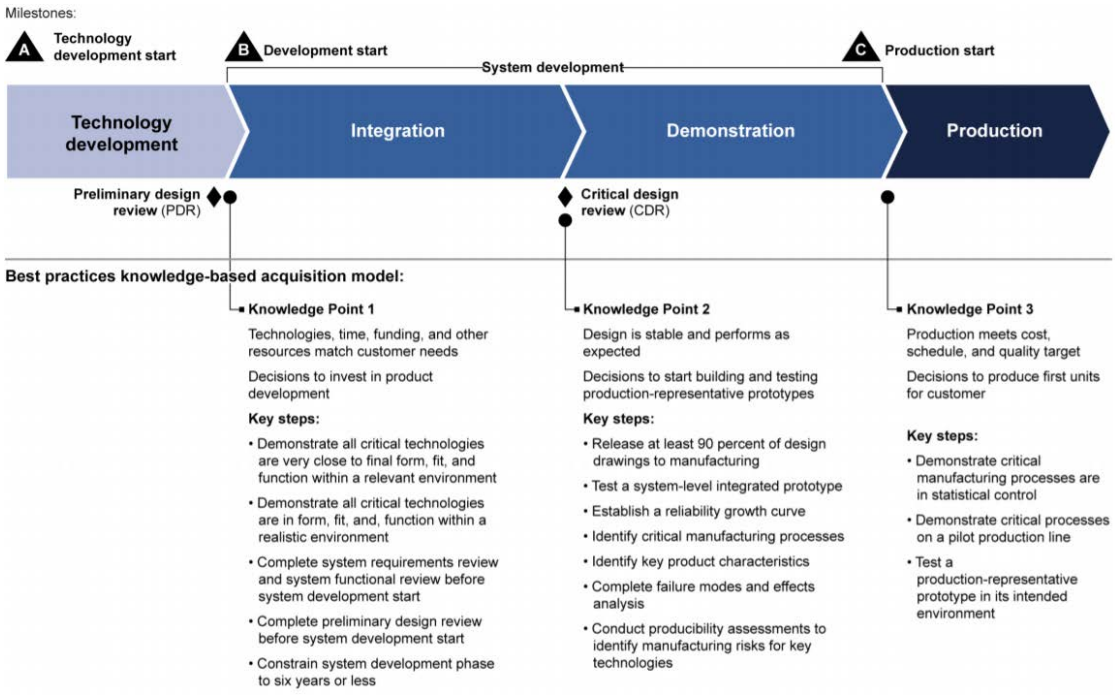

Figure 1. DOD Acquisition Process and GAO-Identified Knowledge Points. Source: GAO (2019, p. 8).

4. The Decline of Assumed Rationality in Decision Making Theory

In a comprehensive RAND study of modern decision science, Davis, Kulick, and Egner (2005) described advancements in decision making theory since 1955 as a "slow, steady retreat" (p. 77) from the assumption of rationality of human decision making. This pivot from assumed human rationality was significantly influenced by the expansive works

of three Nobel Laureates: Herbert Simon (awarded Nobel Prize in 1978), Daniel Kahneman (awarded Nobel Prize in 2002), and Richard Thaler (awarded Nobel Prize in 2017) (Nobel Media, n.d.). Amos Tversky, who died in 1996, would have received the Nobel Prize with Daniel Kahneman in 2002, and his contributions are widely held in the same high regard as Kahneman's (Kahneman, 2002). We highlight the academic stature of these individuals to emphasize that their works are not fringe theories, and they merit serious consideration. The following is a summary of the major developments in decision science theory that pertain to the assumption of human rationality, which is at the center of this research.

a. Rational-Choice Model

Human rationality is a foundational assumption underlying "classic theories in economics, philosophy, linguistics, social science, and psychology" (Lieder, Griffiths, Huys, & Goodman, 2018, p. 1) (See Mill, 1882; Friedman & Savage, 1948; Von Neumann & Morgenstern, 1944; Newell, Shaw, & Simon, 1958; Fodor, 1975; Braine, 1978; Oaksford & Chater, 2007; Lohmann, 2008; Hedstrom & Stern, 2008; Frank & Goodman, 2012; Harman, 2013 [as cited in Lieder et al., 2018, p. 1]). Davis et al. (2005) describe this paradigm of thinking as the rational-choice model (RCM) (Davis et al., 2005, p. 77). Kahneman, Knetsch, and Thaler (1991) describe traditional economics (a.k.a. neoclassical economics) as being built upon the belief that humans behave as rational agents with "stable, well-defined preferences and make rational choices consistent with those preferences" (p. 1; see also Kahneman, 2002, p. 471; & 2011, p. 8). RCM does not differentiate between how humans should make decisions (prescriptive models [a.k.a. normative models]) and how humans actually make decisions (descriptive models), assuming away deviations from RCM as non-relevant outliers (Carter, Kaufmann, & Michel, 2007, p. 633; Rodman, 2015, p. 10).

b. Bounded Rationality

Simon's (1955) groundbreaking theory of bounded rationality was the first significant challenge to the RCM's widely accepted assumption of rationality in human decision making. (Davis et al., 2005, p. 77) Bounded rationality modified RCM, emphasizing the "constraints of time, resources, and cognitive capacity … [which] force

decisionmakers to construct a simplified mental model of the world" (Davis et al., 2005, p. 77; see also Heuer, 1999, pp. 2–3; Kahneman, 2003, p. 1; Davis et al., 2005, pp. 8–9; & Rodman, 2015, p. 13).

c. Heuristics and Biases Paradigm

Building upon Simon's theory of bounded rationality, Tversky and Kahneman (1974) published their seminal work on cognitive biases and heuristics. Their article is one of the most highly cited works in social science, and has been extensively applied in studies of psychology, economics, finance, medicine, legal judgement, intelligence analysis, military strategy, philosophy, and statistics (Kahneman, 2011, p. 8). Their work laid the foundation for Richard Thaler to establish the "then-heretical (and now well-established) view of [behavioral] economics, by using psychological observations to explain violations of standard economic theory" (Kahneman, email communication to Margaret Levi, 20 May 2016; as cited by Gaetani, 2018). Like almost all research on the subject of cognitive biases, this paper heavily draws upon extensive works of Kahneman and Tversky, to include their widely adopted "heuristics and biases approach" (Tversky & Kahneman, 1974; Kahneman, 2002, p. 465). In our judgement, what makes their research influential in so many fields is their extraordinary ability to support their theories and conclusion with large bodies of compelling empirical research. Their cleverly devised experiments and questionnaire sets demonstrated repeatable systemic biases, which made their findings readily accessible and applicable to multiple areas of study. Davis et al. (2005) described this approach as the "heuristics and biases paradigm (HBP)" (p. 13). HBP rejects the assumption that RCM is an accurate descriptor of reality, but generally accepts the RCM's prescriptive/normative models as a standard to assess whether a decision was objectively right or wrong (Davis et al., 2005, p. 78).

d. Naturalistic Paradigm

While the HBP has been widely adopted and built upon by decision science researchers, HBP has received critiques throughout the years, predominately emanating from the works of Gary Klein and Gerd Gigerenzer (Davis et al., 2005, p. 16; Gigerenzer, 1991, 1996; Klein, 2008). According to Davis et al. (2005), criticisms of HBP can be

grouped together into a naturalistic paradigm (NP) school of thought (See also Korteling, Brouwer, & Toet, 2018). NP grudgingly accepts HBP's general descriptions of heuristics and cognitive biases, but it critiques HBP's lab-based research methodologies, use of normative models, the role of expert intuition, and HBP's lack of practical utility as an underlying psychological process (Davis et al., 2005; & Rodman, 2015, pp. 18–19). Conversely, NP values field-based research methodologies, focuses on expert subjects "acting in the domain of their expertise" (Davis et al., 2005, p. 79), rejects normative standards of rationality, and idealizes "choices [made] quickly and intuitively" (p. 80). Essentially, NP embraces the utility of heuristics, and "celebrates biases as adaptive and situation-appropriate" (Davis et al., 2005, p. 17). However, according to Davis et al. (2005) and Kahneman and Tversky (1996), the major conflicts between NP and HBP are more theoretical and diminish upon closer examination. Based on our readings, it would seem that Kahneman has gone to great lengths to answer and address the NP's criticisms, to the extent that we do not believe the two paradigms should necessarily be viewed as mutually exclusive (Kahneman & Tversky, 1996; Kahneman, 2002, 2003, 2011; Kahneman & Frederick, 2002; & Kahneman, Rosenfield, Gandhi, & Blaser, 2016). However, as detailed in this chapter, an in-depth comparison/synthesis of HBP/NP is unnecessary considering the scope of this research.

e. Summary

Why does this matter? Korteling et al. (2018) states "the discovery of cognitive biases and the following doubt on human rationality shakes the foundations of economics, the social sciences and rational models of cognition" (p. 2) (Lieder, Griffiths, Huys, & Goodman, 2017; as cited in Korteling et al., 2018). GAO's incentives narrative implicitly relies upon the RCM paradigm, assuming acquisition participants act logically and rationally to maximize utility in the face of incentives. Davis et al. (2005) warns that viewing human decisions through the RCM paradigm may allow for apt technical descriptions and prescriptive models, but this view would "miss many of the factors that confront real decisionmakers" (p. 6). The contrast between GAO's assumptions regarding incentives and Kahneman's findings related to heuristics and cognitive biases can be compared to the clash between neoclassical economics and behavioral economics.

Neoclassical economics assumes that people are generally rational and respond to incentives (Mankiw, 2007); and explains away deviations from rationality as anomalies or as the result of "emotions such as fear, affection, and hatred" (Kahneman, 2011, p. 8; see also Kahneman, Knetsch et al., 1991) Conversely, due to its reliance upon bounded rationality and HBP, the disruptive field of behavioral economics focuses on how people actually behave (descriptive models), rather than how they should behave (prescriptive models). Charlie Munger, Warren Buffet's longtime business partner, bluntly commented on the divide between neoclassical and behavioral economics stating:

> How could economics not be behavioral? If it isn't behavioral, what the hell is it? And I think it's fairly clear that all reality has to respect all other reality. If you come to inconsistencies, they have to be resolved, and so if there's anything valid in psychology, economics has to recognize it, and vice versa. So I think the people that are working on this fringe between economics and psychology are absolutely right to be there. (Munger, 1995)

The utility of GAO's incentives narrative for explaining and identifying solutions for deviations for sound acquisition practices is greatly reliant upon the narrative's fundamental assumptions, namely the RCM paradigm. If this fundamental assumption is inconsistent with prevailing theories of decision making, then one would expect GAO's incentives narrative to be fundamentally flawed to some extent.

C. PROBLEM

The foundational assumption of human rationality underlying GAO's incentives narrative has come under widespread scrutiny over the past 65 years, which raises concerns regarding the effectiveness of acquisition reform efforts guided by these assumptions. The incentives narrative is a core assumption that GAO, Congress, and the defense acquisition community have relied upon to shape acquisition reform efforts. Many of GAO's recommendations for addressing poor acquisition outcomes have focused on negative incentives which, according to the incentives narrative, result in motivational decision biases. Addressing the incentives highlighted by GAO has proven an intractable problem because these incentives are often engrained into the structure and culture of the Defense Acquisition System (DAS) (Fox, 2009, p. xiii). If cognitive decision biases are at least partly responsible for suboptimal decisions that lead to poor acquisition outcomes, then

current acquisition reform efforts would be ineffective to some extent. In their influential article that has been cited over 36,000 times in published literature, Tversky & Kahneman (1974) state: “This article has been concerned with cognitive biases that stem from the reliance on judgmental heuristics. These biases are not attributable to motivational effects such as wishful thinking or the distortion of judgments by payoffs and penalties [Incentives]” (p. 1131). Further emphasizing their point, they referenced how test subjects exhibited severe judgmental errors despite being encouraged to be accurate and having properly aligned incentives to reward correct answers (Tversky & Kahneman, 1974). So Kahneman—arguably the world’s foremost authority on cognitive biases and Nobel Laureate—has found cognitive biases to often be manifestations of heuristics rather than incentives, even finding that properly aligned incentives did not prevent cognitive errors in judgement. Therefore, it is reasonable to question whether decision biases other than motivational biases (i.e., cognitive biases) play some part in shaping acquisition decisions. If true, even if all of the systemic and intractable incentives identified by GAO were somehow eliminated, doing so would only address the influence of incentive-driven decision biases on acquisition decisions and outcomes. Figures 2 and 3 provide simplified representations of GAO’s incentives narrative and this paper’s thesis.

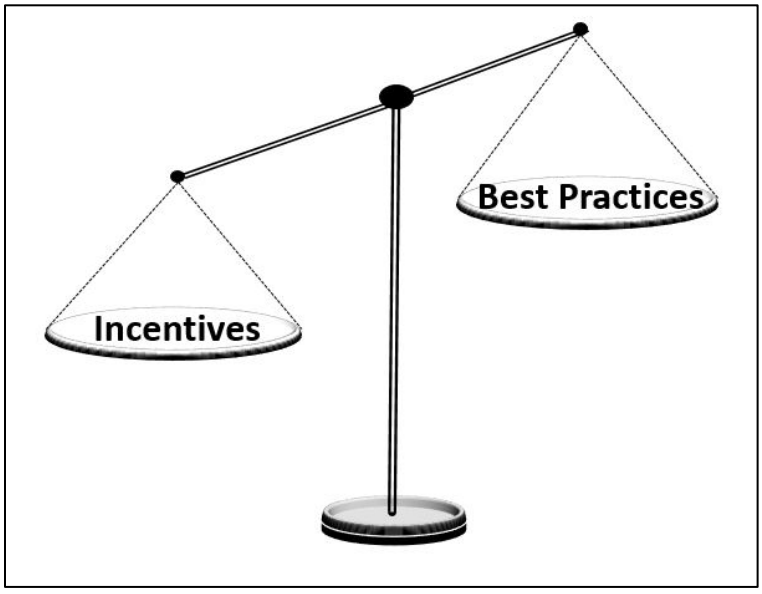

Figure 2. Representation of GAO’s Incentives Narrative

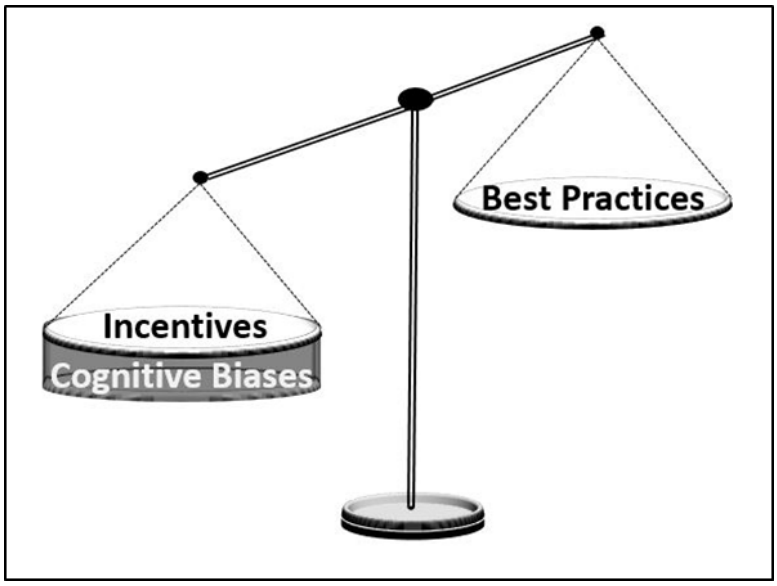

Figure 3. Simplified Representation of Thesis

D. RESEARCH OBJECTIVES

The primary objective of this research is to examine whether cognitive decision biases could also be partly responsible for encouraging deviations from sound acquisition practices. To achieve this objective, we examined a sample of acquisition case studies to identify text passages indicating deviations from sound acquisition practices and/or other well-established normative principles, or situations/decisions that were likely susceptible to decision biases. These passages were then reviewed for indicators of incentive-driven and/or cognitive-driven decision biases using a customized dictionary of common decision biases. The desired end-state for this objective is to highlight the need to further research and ultimately address the influence of various cognitive biases, which may be hindering the implementation of sound acquisition practices and contributing to poor acquisition outcomes. Because of this, we expected that our research would raise more questions and lines of further inquiry than provide definitive recommendations or conclusions.

The secondary objective of this research is to explore the fundamental assumptions, historical development, and empirical research/critical reviews (if any) supporting GAO's incentives narrative. The desired end-state for this objective is to come to a reasonable determination as to the conclusiveness of GAO's incentives narrative, and to assess its

ability to explain the role of decision biases as they pertain to the implementation of sound acquisition practices.

E. RESEARCH QUESTIONS

(1) Primary Research Questions

1. Is it likely that cognitive decision biases significantly contribute to deviations from sound acquisition practices?

2. Is the GAO incentives narrative well-founded and conclusive?

(2) Secondary Research Questions

1. What are some well-established types of cognitive and motivational decision biases; including descriptions, unique attributes, and situational indicators?

2. What are the fundamental assumptions, historical development, and empirical research/critical reviews supporting GAO's incentives narrative?

3. Which cognitive and motivational decision biases may have contributed to deviations from sound acquisition practices in the coded case studies?

F. PURPOSE/BENEFIT

Fundamentally, our research challenges the validity of entrenched assumptions of human rationality underlying GAO's incentives narrative; and seeks to reconcile these assumptions with recent developments in decision science theory, specifically HBP. These groundbreaking theories have fundamentally reshaped the fields of economics and psychology; have been broadly applied to numerous fields of study, to include medicine, law, finance, etc.; and have been extensively applied by the Central Intelligence Agency (CIA) for intelligence analysis (Heuer, 1999), and by the DOD for military strategy. (Kahneman, 2011; Hillemann, Nussbaumer, & Dietrich, 2015; and University of Foreign Military and Cultural Studies [UFMCS], 2016). Considering this, is it reasonable to believe defense acquisition participants are largely unaffected by the cognitive biases that plague

DOD military strategists and CIA intelligence analysts? Our research examines GAO's assumptions and conclusions through the lens of the HBP perspective rather than RCM perspective. By using the HBP perspective, we provide an illustrative view of an alternative narrative to explain widespread deviations from sound acquisition practices.

Let's explore an analogy to further understand the significance and purpose of our research. We've all heard the phrase "Where there's smoke there's fire." In terms of GAO's incentives narrative, the smoke is deviations from sound acquisition practices, the fire is decision biases, and the fuel for the fire is incentives. Not all fires are extinguished in the same way due to their composition; so you hopefully would not attempt to extinguish an electrical fire, lithium battery fire, or a grease fire with the same methods or extinguisher that you would use for a fire composed of wood. Our research questions whether incentives are the only significant source (fuel) for decision biases that lead to deviations from sound acquisition practices. If cognitive biases are fueling a significant number of decision biases, then GAO's longstanding and unwieldy solution to extinguish the problem, removing negative incentives and improving positive incentives, would have little effect on these biases. Returning to our analogy, there is some overlap among the methods that are effective in extinguishing different types of fires. For instance, you cannot extinguish a grease fire with water, but you can extinguish both a regular fire and a grease fire by starving the fire of oxygen. Similarly, you cannot eliminate the influence of purely cognitive biases by removing incentives, but you may be able to mitigate the impacts of both cognitive and motivational biases through various bias mitigation techniques and strategies.

G. METHODOLOGY

To answer the primary and secondary research questions, we performed our analysis in the following roughly sequential phases. First, a thorough literature review was conducted to inform our overall analysis, examine numerous decision bias taxonomies necessary to develop our decision bias dictionary (DBD), identify common types of decision biases, and review the literature relating to GAO's incentives narrative. To ensure we had a sound theoretical understanding and consistent internal schema necessary to

conduct our analysis, we reviewed the expansive body of literature relating to cognitive biases, heuristics, motivational biases, and decision bias theory. Since there is not a widely accepted taxonomy or authoritative dictionary of decision and/or cognitive biases (Rodman, 2015, p. 18), we analyzed numerous decision bias taxonomies in order to determine which decision biases should be included in our DBD. After compiling our customized DBD, we assigned decision bias codes, established transcript coding methodologies, jointly reviewed each decision bias within our DBD, and selected case study transcripts to be coded. Subsequently, we coded our initial transcripts, validated/ updated our coding methodologies and dictionary, coded the remaining transcripts, and compiled/analyzed our findings. A detailed description of the analysis methodologies and data used to answer our primary and secondary research questions is included in Chapter III.

In order to achieve our primary research objective, we needed to assess whether it is likely that cognitive decision biases significantly contribute to deviations from sound acquisition practices (primary research question 1a). To do this, we created a customized DBD of well-established cognitive and motivational decision biases (secondary research question 2a). Using our DBD, we reviewed a selection of case study transcripts to identify text passages indicating deviations from sound acquisition practices and/or situations/ decisions that were likely susceptible to decision biases. We reviewed these passages to assess whether it was likely the decision/situation was likely influenced by one or more decision biases. (secondary research question 2c). This process is detailed further in Chapter III. The intent of our analysis was to provide an illustrative view of the HBP perspective, indicating which (if any) decision biases were likely to have influenced deviations from sound acquisition practices.

In order to achieve our secondary research objective, we needed to assess whether GAO's incentives narrative was well-founded and conclusive (primary research question 1b). To do this, we reviewed relevant GAO reports and major acquisition reform studies' findings concerning defense acquisition culture and incentives to examine the fundamental assumptions, historical development, and empirical research/critical reviews supporting GAO's incentives narrative (secondary research question 2b). To do this, we reviewed

approximately 60 years of relevant GAO reports and major acquisition reform studies' findings concerning defense acquisition culture and incentives.

H. SCOPE/LIMITATIONS

1. Scope

Our research does not seek to disprove the incentives narrative, nor does it seek to prove conclusively that cognitive biases significantly contribute to deviations from sound acquisition practices. Rather, our research seeks to provide an HBP-based alternative to GAO's incentives narrative. We hope to encourage additional inquiries into the adequacy of the incentives narrative's ability to explain why acquisition participants consistently deviate from sound acquisition practices. Since we've found little to no research applying HBP to the DAS, we seek to highlight the need to further research into the influence of various cognitive biases. If DOD determines that cognitive biases significantly contribute to poor acquisition outcomes, then future defense acquisition reformers can begin studying and incorporating various debiasing techniques/structural changes into the broader fabric of reform initiatives.

Based upon the overarching scope of this research, the following describes the specific scope limitations of our analysis. First, GAO and other defense acquisition reform reports have identified a wide range of problem areas that lead to poor acquisition outcomes. However, the scope of our research is limited to issues relating to GAO's incentives narrative and decision biases. Second, this research focuses on assessing whether it is likely that cognitive decision biases significantly contribute to deviations from sound acquisition practices. Therefore, although debiasing techniques are a topic we recommend for further research, this is outside the scope of our research. Third, this paper provides an overview of cognitive biases, heuristics, and motivational biases; however, a comprehensive discussion of the expansive body of research related to behavioral decision theory is outside the scope of this research. Finally, the "nature of the underlying psychological mechanisms that lead to biased behavior is the subject of considerable debate" (Arnott, 2006, p. 59) (See Keren, 1990; Gigerenzer, 1991; 1996; Dawes & Mulford, 1996; as cited in Arnott, 2006, p. 59; see also Hogarth, 1981, 1987; Hilbert, 2012;

& Davis et al., 2005). Considering this, and since our analysis is not contingent upon these underlying mechanisms, it is not necessary for this paper to adopt a particular psychological theory of decision making.

2. Sampled Case Studies

We did not select case studies with the goal of determining the relative influence or impact of assessed decision biases, as compared between positive and negative acquisition outcomes. First, as noted in Sub-Section 3 within this section, determining which—and to what extent—decision biases ultimately contributed to poor acquisition outcomes is outside to scope of our research. Second, as detailed in our "Assumptions" Section, we accept GAO and DOD's assertion that deviations from sound acquisition practices lead to poor acquisition outcomes. Therefore, our research focused only on identifying deviations from sound acquisition practices, and then assessing whether it was likely the decision was influenced by one or more decision biases. This approach did not necessitate comparing cases with positive and negative acquisition outcomes since we were not seeking to compare and contrast these to determine the relative influence or impact of the assessed decision biases. Additionally, although drawing conclusions regarding which decision biases were correlated with poor acquisition outcomes seems ideal, positive outcomes do not prove optimal decisions were made, or that these decisions were driven by knowledge and data (Reference the discussion of the "Success" bias in Chapter II). Explaining the failure of several popular business management books' ability to identify companies that remained successful over time, Kahneman (2011) states "because luck plays a large role, the quality of leadership and management practices cannot be inferred reliably from observations of success" (p. 207). Essentially, it is possible for a decision maker to make the right decision for the wrong reasons. Conversely, an acquisition with poor outcomes may very well have been based on knowledge-based decisions and sound acquisition practices. The Amphibious Combat Vehicle (ACV) case we studied was a good example of this. Although GAO (2018b) stated the ACV program was on track to "meet development cost goals with no additional anticipated delays for major acquisition milestones. … [with costs] on pace to not exceed cost goals that were established at the start of development" (p. 1), we found indications of numerous decision biases within the

case. Therefore, we did not compare and contrast case studies with positive and negative outcomes, and we limited our analysis to identifying and recognizing the likely decision biases associated with acquisition decisions which deviated from sound acquisition practices, regardless of outcome.

3. Subjectivity of Assessing Decision Biases

The process of reviewing case studies, and assessing decision biases is inherently subjective. The following are several unique considerations associated with our review.

First, as detailed in Chapter III, we went to great lengths to ensure the consistency and validity of our coding assessments and methodologies. To accomplish this, we independently coded our first three case study transcripts, compared our results, assessed the root cause(s) of any coding discrepancies (if any), and revised our transcript coding methodologies and DBD accordingly. To ensure consistency, in one instance, we decided to predetermine a selection of assessed decision biases when coding biases related to concurrency strategies, which we encountered multiple times in the same case. However, although we found our independently assessed decision biases to be very consistent, we are cognizant that these assessments are subjective. Biases often may overlap, and multiple biases may be applicable to a single situation or decision. (Arnott, 2006, p. 59). Therefore, differing evaluator assessments are not necessarily indicative of a flawed research approach since the focus of this research does not necessitate absolute precision when differentiating between two distinct, yet similar cognitive biases. The primary focus of our research is to provide an illustrative view of which decision biases (cognitive or motivational) may have contributed to deviations from sound acquisition practices, from an HBP perspective. Therefore, differentiating between these two pivotal categories provided the most significant takeaways. Finally, although debiasing techniques are outside the scope of this research, it is worth noting that the utility of obtaining a high degree of accuracy among similar cognitive biases would be negligible since cognitive debiasing techniques are likely to be effective among similar cognitive biases (Davis et al., 2005).

Second, some decision biases lack a clear consensus among decision bias researchers regarding whether they are driven by cognitive and/or motivational factors.

One significant example of this is the overconfidence bias. Although Tversky and Kahneman (1974) indicated the overconfidence bias to be predominately cognitive, our review of decision science literature, including Kahneman's later works, indicates the overconfidence bias is likely the result of a mixture of motivational and cognitive factors. Kahneman (2011) allows for this view in his description of the excessive optimism in planning forecasts, stating "errors in the initial budget are not always innocent. The authors of unrealistic plans are often driven by the desire to get the plan approved…supported by the knowledge that projects are rarely abandoned unfinished merely because of overruns in costs or completion times" (pp. 250–251). However, a synthesis between these two factors for the overconfidence bias and similar cognitive biases is outside the scope of this research. We recommend this as a focus of further study since the mechanics of the cognitive and motivational factors underlying the overconfidence bias are central to creating a synthesis between HBP and GAO's incentives narrative. While most of the cognitive biases within our DBD are broadly considered to be purely cognitive in nature; Chapter II highlights how some of these biases lack a clear consensus regarding whether they are driven by cognitive and/or motivational factors. In our analysis and conclusions, we sought to highlight the ambiguity, but not necessarily come to a conclusion regarding whether these decision biases were considered cognitive, motivational, or a mixture of the two.

Third, measuring or determining the relative influence or impact of assessed decision biases is outside the scope of this research. This is a valid topic for further study, but the inherent complexity of decision biases renders making such observations very difficult without extensive and controlled empirical research. Rodman (2015) states that "it is difficult to adequately prove the influence of heuristics and biases in field conditions; instead, much of the research in support of heuristics and biases is based on evidence uncovered in controlled laboratory conditions" (p. 20) (Klein, 2008; as cited in Rodman, 2015). Therefore, our research focused on detecting the existence of cognitive biases in our case studies, not measuring their impact. We sought to identify deviations from sound acquisition practices; and then use our DBD to assess, within the context of the decision, whether it was likely the decision was influenced by one or more decision biases.

Fourth, our research is inherently limited by the "Search" bias since some biases that are likely to influence a decision maker are not evident within the format of a GAO case. An example of this is the group of five "Presentation" biases within our DBD. Since these biases are closely associated with how data are presented within actual decision documents or presentations, GAO case studies do not lend themselves well to identifying these cognitive biases.

Finally, our research is limited in its ability to draw specific conclusions regarding the susceptibility of decision makers, programs, or stages of the acquisition cycle to particular decision biases. Attempting to do so would provide a false impression of conclusiveness. While our methodology meets the needs of our analysis, the sample size and other limitations detailed herein limits the extent that our findings can be generalized outside the specific circumstances encountered within each case study. However, we seek to draw tentative conclusions regarding specific circumstances and common themes encountered in our analysis.

I. ASSUMPTIONS

The following is a discussion of the relevant assumptions necessary to conduct our analysis. First, we accept GAO and DOD's assertion that deviations from sound acquisition practices typically lead to poor acquisition outcomes. This assertion is well founded and has been thoroughly examined and validated by GAO and DOD. Second, when reviewing the GAO reports we ultimately used as case study transcripts, we generally accepted GAO's assessments regarding whether the decision(s) in question were deviations from sound acquisition practices. However, we viewed these assessments in light of the DOD and/or Agency response(s) to GAO's findings, and we acknowledge that deviations from sound acquisition practices are sometimes justifiable. Despite this, our research does not attempt to judge whether a decision was good or bad. Our research seeks to identify decision biases that could have led to deviations from sound acquisition practices. Third, we have established GAO and DOD's KBA approach as a normative standard for identifying deviations from sound acquisition practices in our analysis. We also considered additional normative standards such as additional objectively defined sound acquisition

practices; along with widely accepted probabilistic, statistical, logical/rational, etc., normative standards, where applicable. According to Korteling et al. (2018), logical/ rational normative standards may include "non-contradictory reasoning or focusing on, and appropriately weighting relevant information while ignoring irrelevant information" (p. 2). Lastly, we have adopted the heuristics and biases paradigm (HBP) to guide our analysis. We believe HBP is superior to the naturalistic paradigm (NP), both in theory and practical application to the DAS. Since NP philosophically rejects the premise of using normative standards to identify deviations in rational behaviors, using NP would run counter to GAO and DOD's KBA approach and other established normative principles (Davis et al., 2005; Kahneman & Tversky, 1996). However, this decision does not pose a practical limitation since the two paradigms generally agree at a fundamental level, and a HBP/NP synthesis is unnecessary to achieve our research objectives.

J. THESIS STATEMENT

Deviations from sound acquisition practices which lead to poor acquisition outcomes are likely the result of a combination of incentive-driven and cognitive-driven decision biases. Therefore, to improve the implementation of sound acquisition practices, acquisition reform efforts must address both categories of decision biases.

K. REPORT ORGANIZATION

Chapter I provides necessary background and context regarding the focus of this research. Chapter II summarizes the extensive literature review we performed to inform our analysis and to develop our DBD. Chapter III details our analysis methodology and data used to answer our secondary research question 2c, and ultimately answer our primary research questions. Chapter IV discusses the results of our analysis and our findings. Chapter V details our conclusions, and provides recommendations for further research.

L. SUMMARY

This chapter has provided necessary background and context regarding the focus of this research. Next, we examine the varied and expansive bodies of knowledge we reviewed to inform our analysis and to develop our DBD.

II. LITERATURE REVIEW

Chapter I provides necessary background and context regarding the focus of this research. This chapter details the relevant literature we reviewed to inform our overall analysis, reviews various decision bias taxonomies necessary to develop our DBD, identifies common types of decision biases, and reviews the literature supporting GAO's incentives narrative. First, we review relevant GAO reports and major acquisition reform studies' findings concerning defense acquisition culture and incentives in order to evaluate the conclusiveness of GAO's incentives narrative. Second, we examine relevant literature relating to decision biases and heuristics to ensure a sound theoretical understanding and consistent internal schema associated with decision biases. Our review also includes literature relating to decision biases within defense acquisition programs and defense acquisition culture, but our efforts revealed scant literature exists within this focus area. Third, we review several decision bias taxonomies in order to create a customized DBD. Finally, we provide a general overview of many of the significant cognitive and motivational decision biases we included in our DBD and encountered in our analysis.

A. DEFENSE ACQUISITION CULTURE AND INCENTIVES

> Whether the Defense Department's scientists, engineers, and cost analysts will be successful in their efforts to compensate for contractors' optimism can be determined conclusively only through the stern test of time.
>
> —Scherer (1964)

1. Development of GAO's Incentives Narrative

In a seminal study that established GAO's incentives narrative, GAO (1992) reviewed 81 of their previous works on defense acquisition programs from 1976—1991. "To identify the underlying factors [believed to] contribute significantly to recurring acquisition difficulties" (p. 13). The authors found that "occurrences such as performance shortfalls, schedule delays, and cost increases … should also be viewed as the logical consequences of acquisition culture" (p. 35). The report defines defense acquisition culture as the "collective patterns of behavior exhibited by the numerous participants in the

acquisition process and the incentives for that behavior," (p. 2) and stated that this culture has evolved to become "a vehicle for meeting the diverse needs of participants" (p. 2). GAO describes how the cultural participants' needs shape acquisition decisions:

> Weapons have become integral to policy decisions, definitions of roles and functions, justifications of budget levels and shares, service reputations, influence of oversight organizations, distribution of funds to localities, and the industrial base. Programs are also important to individual careers. For example, a program manager's success depends on getting results, and in acquisitions, results mean getting the program through the next major milestone and into the field. Thus, a program manager's strongest motivation is to keep the program moving and to protect it from interruption. … Strong incentives for supporting programs permeate other levels of the acquisition process as well. … To a service branch, it may be perpetuating a mission. To a service, it may be securing its reputation and its share of the budget. To a Member of Congress, it may be responding to constituency interests. To service executives, whose tenures are often relatively short, weapon systems can be an effective way to leave a legacy. (GAO, 1992, p. 38)

The report further states "these needs create incentives for pushing programs and encouraging undue optimism, parochialism, and other compromises of good judgment" (p. 35). GAO also highlights how weak incentives to make difficult choices that may disrupt, restrict, or cancel programs often are overcome by the aforementioned more powerful incentives. In other words, GAO believes the presence of these systemic incentives creates incentive-driven decision biases which lead to poor acquisition outcomes. To mitigate these incentives the report makes two overarching recommendations: "(1) to uproot traditional seats of parochialism and self-interest and (2) to enforce a set of incentives—both positive and negative—to motivate participants to take actions that are consistent with better program outcomes" (pp. 62–63). History, however, has shown the implementation of many of the report's recommendations have failed to achieve the desired results, and little has done to change the fundamental incentives highlighted in the report. DOD officials at the time did not concur with the report's conclusions regarding culture and incentives, attributing poor acquisition outcomes to "a lack of discipline and to the pressures of the Cold War" (pp. 13). Finally, the authors clarified that the report did not represent the "singular correct view of the issues discussed" (p. 2), and made subjective judgements using "corporate knowledge," in order to "extract lessons learned and to

concentrate on the cultural reasons behind persistent problems" (p. 13). It is critical to our analysis to thoroughly note the report's emphasis regarding the inconclusiveness of their findings stating:

> This report does not present the answers; there are no easy ones. However, in the following pages we pose challenges, in the form of questions, we believe can help acquisition participants change the incentives-and the culture-of weapons acquisition. These views necessarily involve judgments and are subject to debate. However, the specifics of these challenges should not overshadow their general intent, which is to spotlight the acquisition culture as a proper focus of prescriptions. (GAO, 1992, p. 59)

We have gone into great detail regarding the 1992 GAO reports findings because it has defined GAO's incentive narrative for the past 25 years.

A thorough review of GAO reports which reference or address the incentives narrative reveals the narrative to be effectively the same as the original incentives narrative proposed by GAO's 1992 report (GAO, 1992; 2004; 2005a; 2013; 2014a; 2014b; 2015b ; 2015c ; 2015d; 2017). In fact, most of GAO's subsequent reports borrow language from large sections of the 1992 report and/or paraphrased sections from each other verbatim (GAO, 1992, 2004, 2005a, 2013, 2014a, 2014b, 2015b, 2015c, 2015d, 2017). Among subsequent reports, descriptions of pressures and incentives, and proposed ways to address them have varied slightly from the 1992 report; however, these variations mainly serve to further emphasize and explain the original report's findings. At first glance, the homogeneity of GAO's commentary on the DOD acquisition culture and incentives may indicate their conclusions are well established and substantiated; however, this view is not supported by the 1992 report itself since it did not claim to be conclusive, and specifically detailed how the study was based upon subjective assessments. Considering this, it seems reasonable to view the uniformity of findings in subsequent GAO reports as a symptom of a subjective organizational assumption that has not been questioned for almost three decades, despite continued poor acquisition outcomes.

Finally, it appears that GAO has failed to consider additional and/or alternative causal influences for decision biases theories developed within the decision science literature in almost any of their published works. We come to this conclusion after

performing multiple Google and Google Scholar Boolean "AND" searches using the term "Government Accountability Office" combined with multiple variations of each of the following terms/authors: "heuristic," "cognitive bias," "decision bias," "Kahneman," "Tversky," and "bounded rationality." Excluding instances where the search term or name was used outside the context of decision theory, only one GAO report on Social Security briefly referenced Kahneman et al.'s (1990) research into the endowment effect (Kahneman et al., 1990; as cited in GAO, 2016c. These results indicate that GAO has not incorporated or even considered more than 60 years of fundamental advances in behavioral decision theory.

In summary, GAO believes poor acquisition outcomes are partially the result of various incentives that favor optimistic perspectives that compromises good judgment when making decisions. A review of the history of GAO's published commentaries on DOD acquisition culture and incentives strongly suggests GAO's incentives narrative is almost solely based on a GAO report conducted more than 25 years ago. We also found this report did not represent itself as conclusive, admittedly based its conclusions on subjective judgements and "corporate knowledge," and was intended to spur further inquiry and debate (GAO, 1992). In spite of this, it appears the 1992 report's conclusions have largely persisted unchanged and unchallenged for over 25 years, despite continued poor acquisition outcomes.

2. Influential Acquisition Reform Reports

This section examines other influential acquisition reform studies and reports' findings and conclusions concerning defense acquisition culture and incentives to create a better contextual understanding of GAO's assumptions. To do this, Fox and Schwartz's excellent overview on historical DOD acquisition reform efforts was reviewed to identify influential acquisition reform initiative reports and studies which address elements of the incentives narrative (Fox, 2011; Reform of the Defense Acquisition System, 2014). This analysis covered DOD acquisition reform efforts spanning 60 years, starting with the three-year Harvard research project, began by Peck and Scherer in 1959, and ending with the now defunct Better Buying Power initiatives which ended in 2015 (Fox, 2011, p. 35; GAO,

2019, p. 143). Although not an exhaustive overview, the following sections highlights significant acquisition reform studies and reports' findings and conclusions relating to our research. Although we endeavored to keep each report's findings within its' original context, we viewed each report using both the rational choice model (RCM) underlying GAO's incentives narrative, and the heuristics and biases paradigm (HBP). Accordingly, in the following sections, we include parenthetical references to decision biases that are related to the respective report's finding, where applicable. The referenced decision biases are discussed in detail in Chapter II, Sub-Section D/E and Table 2.

a. 1962—The Weapons Acquisition Process: An Economic Analysis

Merton Peck and Frederic Scherer of Harvard University conducted a three-year research project on the economic factors underlying the DOD weapons acquisition process (Fox, 2009). These efforts culminated in the following two volumes: *The Weapons Acquisition Process: An Economic Analysis* (Peck & Scherer, 1962), and *The Weapons Acquisition Process: Economic Incentives* (Scherer, 1964). Citing the six fundamental problems studied by Peck and Scherer, Fox (2009) points out that acquisition reform efforts have continued to attempt to solve the same intractable problems as Peck and Scherer. While Peck and Scherer acknowledged the importance of empirical and statistical research, they stated that due to limitations imposed by time, manpower, and the nature of the subject matter; their primary research method was compiling detailed "case studies of 12 advanced weapon system and 7 commercial product development programs" (Scherer, 1964, p. 12), spanning from 1945–1960.

In the first volume, Peck and Scherer (1962) extensively described and analyzed the DOD acquisition process, and the nature of the competitive forces and other environmental factors that influence this process. Although Peck and Scherer do not specifically discuss defense acquisition culture or key elements of the incentives narrative, the following findings and conclusions are relevant to our research subject.

Peck and Scherer detailed an interaction between objective analysis and subjective interpersonal confidence when facing technological uncertainty, stating "a good technical feasibility evaluation must consider not only the state of the art in a very objective sense,

but also the competence, insight, motivation, and other characteristics of those who propose to develop the weapon" (1962, p. 246). Citing two examples of programs studied, they further suggested that "when technological uncertainty is substantial, it may be desirable to base weapons program decisions on something resembling interpersonal confidence rather than, or as well as, on objective analysis" (Peck & Scherer, 1962, p. 246). Peck and Scherer deemed the value of subjective interpersonal confidence and knowledge of objective technical considerations to be greatest at the lower organizational levels such as the individual services. However, they also cautioned that "subjective confidence is not an infallible predictor of success … [and] the individual services have been less than completely impartial in their analysis of the 'objective' data, and they have often failed to represent the broad national interest, especially when advocating their own weapons systems in the face of interservice rivalries" (Peck & Scherer, 1962, pp. 248–249) (Reference discussion of "Misaligned Perception of Corporate Goals" and "Selectivity" decision biases in Chapter II, Sub-Section D/E and Table 2). However, while they characterized DOD-level program decisions as generally more objective, they also cautioned against the "propensity of functional groups to ignore important parts of the problem in their analyses" (p. 249) (Reference "Attenuation" and "Selectivity" decision biases). If their assessment of the influence of subjective interpersonal confidence in the face of technological uncertainty is accurate, it is highly likely that such assessments could be clouded by a broad spectrum of cognitive and motivational decision biases.

Peck and Scherer (1962) concluded that uncertainties that negatively impact the quality of program decisions stemmed "partly from the optimistic bias of program advocates" (p. 322) (Reference "Overconfidence" and "Misaligned Individual Incentives" decision biases). They also concluded that, while a program decision model that seeks to select programs which offer the greatest overall value "is applicable for descriptive purposes and may have some value in actual decision making" (p. 322); "as the level of [program] investment accumulates, its utility becomes circumscribed by political and psychological considerations" (Peck & Scherer, 1962, p. 322) (Reference "Escalation," "Misaligned Individual Incentives," and "Misaligned Perception of Corporate Goals" decision biases). These findings are relevant to our research subject since they allude to a

decision making environment that is significantly influenced by motivational and cognitive decision biases.

b. 1964—The Weapons Acquisition Process: Economic Incentives

In the second volume, Scherer (1964) examined the role of contractual and competitive incentives associated with defense acquisition programs. This volume's focus is primarily on contractor incentives, and does not specifically discuss defense acquisition culture or key elements of the "incentives narrative." However, the following findings regarding contractor behaviors are likely analogous to their government counterparts.

First, Scherer described the tendency of contractors to maintain the status quo: "a technical group tends to become committed to a certain approach or solution to a problem, and as long as it works satisfactorily, no serious effort is made to seek fundamentally better solutions" (p. 23). Scherer found this tendency toward the status quo to be less severe when spurred by significant technical competition, and detailed valid reasons and situations why a contractor may make a rational decision to maintain the status quo. However, he further referenced examples where contractors irrationally clung to an objectively inferior technical approach, rationalizing away and/or ignoring the threat of the rival technical approach (1964, p. 25) (Reference "Conservatism" and "Attenuation" decision biases).

Next, of the programs studied, Scherer (1964) found that cost prediction errors resulted in an average 220% cost overrun, and were largely driven by "competitive optimism" (p. 27; see also Peck & Scherer, 1962) (Reference "Misaligned Individual Incentives" decision bias). Citing contractors' competitive optimism, Scherer (1964) emphasized the importance for government personnel to "independently adjust contractor estimates to a more realistic basis" (p. 29), but expressed doubt in the government's ability to do this, stating "technical personnel have been somewhat optimistic about their ability to identify contractors' optimism" (p. 29) (Reference "Overconfidence" decision bias and related discussion of the "Dunning-Kruger effect"). Scherer also noted government program personnel represented another significant source of cost prediction errors:

> Government operating agencies have often encouraged contractors to estimate costs optimistically, recognizing that higher headquarters might be

> shocked out of supporting a program whose true costs were revealed at the outset. They have sought to disclose cost increases only gradually, after programs have gained momentum and cancellation has become difficult. (1964, p. 28) (Reference "Strategic Misrepresentation" decision bias)

Scherer found that in either case, "decision makers at higher levels … often lacked the technical expertise needed to adjust contractor and operating agency cost estimates to a more realistic basis" (1964, p. 28) (Reference "Overconfidence" decision bias and related discussion of the "Dunning-Kruger effect").

Lastly, Scherer (1964) noted that contractor and government acquisition participants systematically underestimated the risk that adding additional and sometimes unnecessary technical elements would pose to the development of the overall system. Scherer quoted former Secretary of Defense, Robert McNamara, stating "He criticized the tendency of military planners 'to forget that every additional bit of complexity you add to your operation tends to degrade … over-all efficiency" (1964, p. 37) (Reference "Conjunction" decision bias).

c. 1970—Blue Ribbon Defense Panel (Fitzhugh Commission)

According to Fox (2009) the Blue Ribbon Defense Panel (a.k.a. Fitzhugh Commission) was established in 1970 by President Richard Nixon. This panel's charter was very broad, but included reviewing "department procurement policies and practices as they related to costs, time, and quality" (Fox, 2009, p. 46; DOD, 1970). The report had little to say with respect to the incentives narrative, briefly alluded to an element of the incentives narrative, and highlighting the problem of parochialism in defense acquisition program. In a discussion of the limitations of cost estimates, the report briefly alludes to an element of the incentives narrative, stating "Other factors, however, also contribute to the inaccuracies of cost estimates. The understandable incentives to sell a development program, either to senior decision-makers in the Executive Branch or to Congress, can influence cost estimates to be on the low side" (DOD, 1970, p. 83). However, the report does not elaborate on this topic further. Lastly, the report touches on the problem of parochialism within DOD. As detailed further within this chapter, DOD and GAO's descriptions of parochialism align with the definition of the "Misaligned Perception of

Corporate Goals" motivational bias within our DBD. The report describes the problem of parochialism as follows:

> The evolution of defense organization since 1947 has not substantially reduced the inherent difficulties arising from the fact that the division of roles and missions among the Military Departments is still based fundamentally on distinctions between land, sea and air forces which have become increasingly less relevant. This results in continued adversary relations between the Military Services, which … severely inhibit the achievement of economy and effectiveness required for adequate defense within available resources. The continuing interservice competition seriously degrades the decision-making process through obfuscation of issues and alternatives, and leads to attempts to circumvent decisions, repeated efforts to reopen issues that have already been decided, and slow, unenthusiastic implementation of policies to which a Service objects. (DOD, 1970, p. 21)

d. 1972—Congressional Commission on Government Procurement

The Congressional Commission on Government Procurement was appointed by Congress in 1972 to "identify the causes of weapons cost overruns and to propose new methods of cost control" (Fox, 2009, p. 41). The commission's report included discussions on three intertwined concepts that are relevant to our research: parochialism, concurrency, and program advocacy. The report states "Entire system costs cannot be estimated realistically during its early development. Institutional arrangements [i.e., parochialism] and advocacy pressures tend to drive cost estimates downward and to produce overly optimistic schedule and performance appraisals" (DOD, 1972, p. 99). The report identifies six factors that cause "avoidable cost increases" (p. 100). Two of the six are 1) system advocacy (i.e., program advocacy) and premature commitment, and 2) concurrency strategies. We believe the first of these two, identified as "system advocacy and premature commitment" (p. 100), incorrectly conflates these two concepts. While we believe these concepts can and likely often co-occur, we do not believe they are mutually inclusive concepts. Setting this aside, we found the report strongly emphasized the concept of program advocacy as a fundamental factor in overly optimistic cost, schedule, and/or performance estimates stating: "Acquisition planning often has relied on cost and schedule estimates prepared by advocates of a proposed new system. The advocates understandably tended to minimize unknowns and defer the resolution of uncertainties to later stages"

(DOD, 1972, p. 104). From an RCM perspective, this statement clearly describes incentive-driven behaviors, consistent with GAO's incentives narrative. However, from an HBP perspective, these decisions might have been influenced by a motivational bias such as "Misaligned Perception of Corporate Goals" bias. However, the HBP perspective would also consider whether these decisions were also influenced by cognitive biases such as the "Desire," "Overconfidence," "Attenuation," and "Complexity" biases (to name a few). The report further describes program advocacy stating "All levels in a department, in industry, and even in Congress can become parties to the 'selling' of programs founded on unrealistic and unattainable system cost goals" (DOD, 1972, pp. 99–100). Second, the report describes a practice we encountered prevalently in our literature review and analysis, concurrency. The report describes this practice as follows:

> Committing to extensive production when much development, test, evaluation, and redesign still remain to be done usually leads to major retrofit and modification costs. Components, equipment, and tools can be made obsolete by design changes as the development progresses. (DOD, 1972, p. 100)

The report identifies initial operational capability deadlines as commonly pushing a program to implement concurrency strategies. Lastly, the report also suggested that overly optimistic cost estimates might be the result of parochialism:

> Competition exists among programs intended to fulfill the same organizational missions and between proposed new programs and ongoing programs. Each agency component must "sell" its programs in order to maintain or enhance its capabilities and future status" (p. 104)

The report concluded "Some increase from an initial estimate for a major system is almost certain to occur" (p. 111), and identified optimism of program advocates as an inevitability that "should be compensated for in estimates" (DOD, 1972, p. 111). We found the report's findings and conclusions relating to program advocacy and parochialism to be most closely related to GAO's incentives narrative.

e. 1986—Blue Ribbon Commission (Packard Commission)

According to Fox (2009), in 1985, President Ronald Reagan appointed the Blue Ribbon Commission on Defense (a.k.a. the Packard Commission) to "review the entire

weapons acquisition process and recommend reforms for improvement" (p. 120). However, Fox's summary and our own review of the report's findings touched on the topics of acquisition culture, incentives, or other subjects directly relevant to our research (Fox, 2009; DOD, 1986).

f. Conclusion

According to Fox (2009), the 1992 GAO report that established GAO's incentives narrative "was unique among acquisition reform studies in that it stressed the impact of the acquisition culture" (p. 189). As far as we could find, this statement by Fox is correct. Our review of these influential acquisition reports indicate the incentives narrative (within the context of defense acquisition) was established by GAO's 1992 report. We found the aforementioned acquisition reform reports provided insights into topics relevant to our research, such as program advocacy, overconfidence, concurrency, and parochialism. However, while these insights provide context and background relating to our analysis and findings, we found no report that directly contributed to or provided empirical research to establish or support GAO's incentives narrative.

B. DECISION BIASES AND HEURISTICS

1. System 1 / System 2 Theory

Kahneman (2011, p. 13) used the metaphor of the mind operating as two systems, System 1 and System 2. He based his work off of William James' dual-process theory, and used the metaphor first coined by Stanovich and West (2000). Kahneman (2011) describes System 2 as the "slow" rational deliberate system. This is the function of our minds we are most familiar with. He describes System 1 as the "fast" intuitive system that is responsible for influencing much of our decisions we attribute to the rational workings of System 2. The workings of these two systems can easily be seen through the experience of learning to drive a car. At first, our System 2 brain is responsible for making sure our hands are positioned correctly on the steering wheel, consciously thinking about which pedal to push, etc. However, most adults subconsciously end up delegating this task to System 1, making the process seem intuitive and automatic. System 1 is largely responsible for the learning curves we see while a person intuitively masters a task. However, to remain efficient,

System 1 must develop heuristics to operate in a world where our senses are bombarded with millions of unique stimuli throughout our lives. Heuristics themselves are necessary to live, and enable us to quickly react on limited information. However, much of the cognitive biases Kahneman details are the results of these heuristics. In his book, Kahneman also detailed how, when prompted, System 2 can take over and correct for a System 1 error. For instance, at the sound of a balloon popping behind us, our System 1 takes over, and we jump; but then System 2 takes over, and we are able to compose ourselves. The System 1 / System 2 theory is the foundation Kahneman and Tversky's work was built upon, with regard to cognitive biases (Kahneman, 2011)

2. Heuristics

Kahneman and Frederick (2002) provide a simple explanation of heuristics, followed shortly thereafter by a very technical definition of generic heuristic processes:

> When confronted with a difficult question people often answer an easier one instead, usually without being aware of the substitution. … We will say that judgment is mediated by a heuristic when an individual assesses a specified target attribute of a judgment object by substituting another property of that object -- the heuristic attribute -- which comes more readily to mind. Many judgments are made by this process of attribute substitution. … Because the target attribute and the heuristic attribute are different, the substitution of one for the other inevitably introduces systematic biases. (pp. 4–5)

The use of intuitive judgements and heuristics is inherently human, and does not necessarily lead to poor decisions. According to Kahneman, it is often difficult to distinguish between heuristic-driven intuitive judgements and expert judgements supported by prolonged practice and adequate feedback (2011, pp. 11, 242). For instance, a chess master relies on expert intuition, rather than heuristics when making decisions. Requiring a chess master to justify his/her ability to instantaneously read the condition of a game in play, or to explain every move in context with his/her overall strategy would be counterproductive. The converse problem occurs when experts make judgments based on simplifying heuristics, but believe their decision was based on expert intuition. However, the naturalistic school of thought would argue heuristic-driven intuitive judgements and expert judgements are both driven by heuristics (Davis et al., 2005). Nevertheless, both

schools of thought (HBP & NP) agree that when evaluating the efficacy of an expert's intuition, "subjective confidence is not a good diagnostic of accuracy [because] judgments that answer the wrong question [i.e., heuristics] can be made with high confidence" (Kahneman, 2011, p. 243). In addition, the use of heuristics can be appropriate in certain situations which require quick decisions, and where the methodical process of deliberation would result in disastrous inaction. Making these distinctions can be difficult, and requires further study to effectively mitigate bias within decision making without accidently stripping the process of expert intuition or the appropriate use of heuristics. Tversky and Kahneman (1974) initially described three fundamental heuristics which lead to judgmental biases/fallacies: representativeness, availability, and adjustment and anchoring. Kahneman later incorporated the affect heuristic, proposed by Slovic, Finucane, Peters, and MacGregor (2002), to this list (Kahneman & Frederick, 2002; Kahneman, 2003, 2011).

C. DECISION BIAS TAXONOMIES

Since there is not a widely accepted taxonomy or authoritative dictionary of decision and/or cognitive biases, we reviewed several decision bias taxonomies in order to adapt them into a customized DBD. The decision bias taxonomies we reviewed were judged based on our subjective assessment of each taxonomy's comprehensiveness, descriptiveness, empirical/research support, and utility of the taxonomy's classification strategy. We also favored taxonomies that were simple, logical, and independent of a particular theoretical model. Table 1 lists the taxonomies we reviewed in alphabetical order.

Table 1. Decision Bias Taxonomies Reviewed

Reviewed Taxonomy Reference	# of Identified Decision Biases	# of Identified Bias Categories
Arnott (1998, 2006)	37	6
Baron (1988)	53	5
Bazerman & Moore (2009)	12	3
Carter, Kaufmann, & Michel (2007)	76	9
Hilbert (2012)	8	-
Hogarth (1987)	38	4
Tversky & Kahneman (1974)	20	3

Reviewed Taxonomy Reference	# of Identified Decision Biases	# of Identified Bias Categories
Lovallo & Sibony (2010)	17	5
Montibeller & Winterfeldt (2015)	26	3
Remus & Kottemann (1986)	24	5
Virine & Trumper (2007)	69	10

Although not a taxonomy, a single bias was added from Jones and Euske (1991).

From our review, we ultimately assembled a customized DBD consisting of 44 individual biases, divided into 8 bias categories; which drew largely from Arnott's (1998, 2006) taxonomy, partly from Lovallo and Sibony's (2010) taxonomy, and a single bias was added from Jones and Euske (1991) after the analysis had begun.

Arnott's (1998, 2006) taxonomy of 37 individual cognitive biases, which was divided into 6 bias categories, became the backbone of our DBD. We readily accept that Arnott's taxonomy is not perfect, but Arnott's taxonomy fits for our research needs for the following reasons: 1) It can be applied to many models of behavioral decision theory, but is not beholden to any particular one (1998, p. 33). 2) It is logical and internally consistent. 3) It identifies decision biases that are generally accepted and supported by empirical evidence rather than theoretical conjecture (1998, p. 3). 4) It is practically organized due to its intended use within the applied discipline of decision support systems (DSS) (1998, p. 30). 5) It critically examines and incorporates elements of many other decision bias taxonomies (1998, pp. 23–33). 6) It helpfully provides cognates (synonymous, similar, or related decision biases) for each bias to allow for consistency among the widely varying and overlapping terminologies used within various fields of study (1998, p. 23). 7) Finally, although this was not originally a consideration, we found a comprehensive RAND study of modern decision science (Davis et al., 2005, p. 13) to have also largely adopted Arnott's taxonomy. Davis et al. (2005) clarified that Arnott's taxonomy consisted of "unmotivated biases, as distinct from motivated biases" (p. 13).

Since the Arnott taxonomy did not include motivational or social biases, the remaining seven individual biases and two bias categories were adopted from two other sources. Six of the remaining individual biases and two bias categories were incorporated

from Lovallo and Sibony's (2010) taxonomy. Finally, since we did not have a term to describe the incentive-driven behaviors detailed in our third case study, strategic misrepresentation (Jones & Euske, 1991) was incorporated at that time. While strategic misrepresentation is a conscious decision rather than a cognitive or motivational bias, it is relevant to our research because the behavior is typically incentive-driven (Jones & Euske). Therefore, for simplicity, strategic misrepresentation has been classified as a motivational bias.

D. COGNITIVE DECISION BIASES

This section will provide an overview of several specific cognitive decision biases we encountered most prevalently in our analysis and will provide the reader with a foundation for the discussion of our findings in Chapter IV. For each bias, we provide a brief summary of the bias; an example of how the bias could manifest in a DOD weapon system acquisition environment; and a selection of relevant research, along with any situational indicators and/or conditions where the bias is likely to occur. It is important to note here that the cognitive biases within Arnott's taxonomy "are not necessarily as discrete as the taxonomy implies, and that they are likely to overlap in definition and effect" (2006, p. 59; see also Carter et al., 2007, p. 634; Sage, 1981, p. 3.14). In addition, as detailed in Chapter I, for biases lacking a clear consensus regarding whether they are purely cognitive, we detail the ambiguity and recommend further study. As discussed in Chapter I, the body of knowledge and experimental evidence relating to cognitive biases is vast, robust, and is generalizable to a broad range of fields of study (Heuer, 1999, p. 113). However, considering the limited scope of this research, the discussion of each bias is limited to a general overview in order to provide the reader with a foundation for the discussion of our findings.

1. Anchoring and Adjustment

Arnott (1998) summarizes the anchoring and adjustment bias (a.k.a. anchoring and adjustment heuristic) as follows: "Adjustments from an initial position are usually insufficient" (p. 4). This bias comes from a tendency to root oneself to an initial value, and then fail to adequately adjust for subsequent information when making decisions.

Individuals suffering from this bias will use a focal point as a reference (anchor), but rely too heavily or fail to appropriately adjust from this reference point, even when it is random or arbitrary, which can ultimately have a serious impact on the decision they ultimately make (Arnott, 1998, 2006; Tversky & Kahneman, 1974; Kahneman, 2011). Although the use of anchors in making decisions under uncertainty is not inherently irrational, failing to appropriately adjust from an anchor, especially when the anchor is random or arbitrary, is not considered a result of a rational choice.

The following is a selection of relevant research associated with the anchoring and adjustment bias. Tversky and Kahneman (1974) found test subjects estimated the product of "1 x 2 x 3 x 4 x 5 x 6 x 7 x 8" at a median estimate of 512, but another group of test subjects estimated the product of "8 x 7 x 6 x 5 x 4 x 3 x 2 x 1" at a median estimate of 2,250. They also found test subjects' estimates of the percentage of African nations in the United Nations were influenced higher or lower by observing a number on a rigged wheel of fortune that they used as an arbitrary anchor (p. 1128). Kahneman (2011) details how this bias, even when it is random or arbitrary, can affect our ability to accurately estimate age, length and volume (Leboeuf & Shafir), and temperature (Mussweiler & Strack); realtors' estimates for the value of a house (Northcraft & Neale); and even prison sentences assessed by judges (Guthrie, Rachlinski, & Wistrich, 2002) (Kahneman, 2011, pp. 119–127). Joyce and Biddle (1981) found the professional judgement of experienced auditors to be influenced by the manipulation of "normatively irrelevant" anchors (p. 144). However, there are limits to this bias. Chapman and Johnson (1994) found the presence of the anchoring and adjustment bias was reduced or eliminated in the presence of "implausibly extreme" anchors or with anchors presented on "incompatible scales" (pp. 1,4). In terms of the Kahneman's (2011) discussion of heuristics and the System 1/System 2 theory, Chapman and Johnson's findings could be explained as System 2 overriding a System 1 error.

2. Attenuation

Arnott (1998) summarizes the attenuation bias (a.k.a. best guess strategy & ignoring uncertainty) as follows: "A decision making situation can be simplified by

ignoring or significantly discounting the level of uncertainty" (p. 5; see also Carter et al., 2007, p. 636). This bias acts to oversimplify a decision making process by ignoring, overlooking, or excluding information (or other uncertainties) relevant to the decision. (Arnott, 1998, 2006). For example, a weapons program could suffer from this bias if decision makers oversimplify or discount the level of risk or vulnerabilities associated with the system's or sub-systems' susceptibility to cybersecurity threats. While limiting the amount of information considered is a fundamental and necessary mental process when making efficient judgements under uncertainty, attenuation is not logical because a decision maker should not arbitrarily or inconsistently ignore possibly relevant information when making a decision.

The following is a selection of relevant research associated with the attenuation bias. Describing a similar phenomenon, best-guess strategy, Gettys, Kelly, and Peterson (1973) found physicians were more likely to ignore the possible implications of less likely events, instead following the optimal probabilistic decision model. Gettys et al. found that test subjects exhibited a predictable "inappropriate response of concentrating almost exclusively on the intermediate hypothesis which was his best guess" (1973, p. 7). Next, Slovic (1975) analyzed how test subjects chose between two alternatives, each with differing advantages and disadvantages for primary and secondary characteristics. The first alternative was designed to be advantageous for a primary characteristic, but had a secondary characteristic that was "so inferior … that this disadvantage canceled its [overall] advantage" (p. 280); and vice versa for the second alternative. Slovic found that test subjects exhibited a "reliance on easily justifiable aspects to the neglect of other important factors could lead one to reject alternatives whose overall utilities (assessed outside the choice context) are superior to those of the chosen alternative" (1975, p. 287). Finally, Stoker (1996) described the attenuation bias as an expected statistical mathematical function, where attenuation is explained by the process of "data smoothing" (eliminating statistical noise or outliers from data) when predicting a random variable. In other words, Stoker concluded that the attenuation bias arises when a decision maker eliminates what he/she determines to be unimportant or unlikely variables in a decision.

3. Complexity

Arnott (1998) summarizes the complexity bias (a.k.a. decision environment) as follows: "Time pressure, information overload and other environmental factors can increase the perceived complexity of a task" (p. 7; see also Carter et al., 2007, p. 636). Hogarth (1987) defines this bias as follows: Complexity induced by time pressure, information overload, distractions lead to reduced consistency of judgement … [and consequently] information processing may be quite superficial" (p. 220). The complexity bias occurs when decision quality is negatively affected by environmental factors (a.k.a. task stress) such as time pressure, perceived importance of the decision, an overwhelming amount of data, inputs required from many stakeholders, and/or the novelty of the decision. (Arnott, 1998, 2006). The Yerkes-Dodson Law describes the relationship between task stress and decision quality as a bell curve, where decision quality increases with task stress to a point, but then decreases as task stress increases beyond this point (Yates, 1990; as cited by Arnott, 1998). Since environmental factors such as time pressure, novelty of decisions, information overload, importance, voluminous data, etc., are a practically defining characteristics of weapons programs, a milestone decision authority's decision quality is likely to suffer from excessive task stress when assessing whether a program should move to the next phase of the acquisition process. While the Yerkes-Dodson Law makes intuitive sense, the quality of purely rational decisions should not vary based upon the level of task stress.

The following is a selection of relevant research associated with the complexity bias. Pollay's (1970) experimental findings contradicted the normative assumption that decision time increases directly with the difficulty of a decision problem. Pollay found that test subjects took more time to choose among four good alternatives, but took less time to choose among two inferior and two good alternatives. However, when additional complexity was introduced (describing the alternatives along eight versus two dimensions), the results were reversed, indicating test subjects were more likely to give up or choose hastily when asked to choose among four complex good alternatives (Pollay, 1970). Next, Wright (1974) found that when decision makers are faced with environmental factors such as time pressure, distraction, or information overload; they were prone to compensate by

using simplifying strategies that deviated from the "optimal rational strategy" (p. 560). In other words, Wright found that when faced with task stress, decision makers often resort to using satisficing strategies and shortcuts, which in this study, manifested as subjects placing a disproportionate weight on negative evidence (Wright, 1974; see also Einhorn, 1971). Additionally, Payne (1982) concluded that "information processing in decision making is highly contingent on the demands of the task" (p. 399).

Maule and Edland (1997) found that decision makers altered their decision making processes when faced with time pressure. These alterations included reducing decision quality, modifying risk-taking tendencies, focusing on personal knowledge versus external sources of information, altering underlying cognitive processes, placing disproportionate weight on different information sources and/or positive versus negative information sources, and "reducing the overall attractiveness of alternatives" (Maule & Edland, 1997, p. 201; see also Ordonez & Benson, 1997). In other words, decision makers resorted to a wide range of simplifying mental shortcuts (heuristics) when faced with time pressure (See also Pitz & Sachs, 1984, pp. 145–146).

4. Conjunction

Arnott (1998) summarizes the conjunction bias (a.k.a. inertial ψ effect) as follows: "Probability is often over-estimated in compound conjunctive problems" (p. 8; see also Carter et al., 2007, p. 637). Humans are terrible intuitive statisticians, and the same can even be said of professional statisticians (Kahneman, 2011, p. 5). According to Arnott, building projects and complex system development programs are particularly vulnerable to the conjunction bias because multiple constituent elements must be completed on time and correctly for the end product to be completed on time (1998; see also Arnott, 2006). Therefore, this bias is likely to exist in the defense acquisition environment since, according to Fox (2009), "Major weapon systems development and production programs are technologically advanced and complex … [and] are often designed to achieve performance levels never before realized, using many components and some materials never before used in military applications" (p. 6). For example, for a major weapon system where several milestones on the project's critical path must be completed on schedule for

the final system to be completed on time, the conjunction bias systematically encourages acquisition participants to underestimate the likelihood of schedule delays. In fact, major weapon system acquisitions are uniquely at risk of succumbing to the conjunction bias because these systems can have scores of sub-systems and thousands of constituent elements that have to all work together (Fox, 2009). In a normative probabilistic sense, the conjunction bias is irrational because decisions relying upon assessments of probability should line up with objective probabilities.

The following is a selection of relevant research associated with the conjunction bias. Tversky and Kahneman (1974) made the following observation: "Studies of choice among gambles and judgments of probability indicate that people tend to overestimate the probability of conjunctive events and to underestimate the probability of disjunctive events" (p. 1129). Bar-Hillel (1973) presented test subjects with a choice of variations of the following three probabilistic events: 1) Pick one red marble out of a bag of 50 white and 50 red marbles (i.e., a simple event with an objective probability of 50%), 2) Pick seven red marbles in a row out of a bag of 10 white and 90 red marbles (i.e., a conjunctive event with an objective probability of 48%), or 3) Pick at least one red marble in seven tries out of a bag of 90 white and 10 red marbles (i.e., a disjunctive event with an objective probability of 52%) Contrary to what the objective probabilities would dictate, Bar-Hillel found test subjects consistently chose the conjunctive events most often, simple events next, and disjunctive events least. (1973; as cited by Tversky & Kahneman, 1974). Next, using the cognate, inertial ψ effect, Cohen, Chesnick, and Harlan (1972) found test subjects tended to "overestimate compound probabilities, in the rough sense that they think they have a better chance of success than is actually the case" (p. 41); and concluded that the mind's grasp of compound probabilities is far from intuitive, which results in a predictable systemic error. Finally, Teigen, Martinussen, and Lund (1996) were able to replicate previous research findings relating to the conjunction bias, but concluded that while the conjunction bias was prevalent, it was not necessarily universal. Teigen et al. found that the severity of the conjunction bias varies based upon the "type of probability (fictional versus [real life events]), unequal versus equal probabilities of constituent [i.e., simple events making up the compound-conjunctive probability] events, predictions of positive

versus negative outcomes, and, for real-life predictions only, number of constituent events" (1996, p. 77). (See also Bazerman, 1990, 1998; Kahneman, 2011; Kahneman & Tversky, 1982; Yates, 1990)

5. Conservatism

Arnott (1998) summarizes the conservatism bias as follows: "Often estimates are not revised appropriately on the receipt of new significant data" (p. 9; see also Carter et al., 2007, p. 637). Arnott elaborates further that this bias occurs when an individual resists or ignores new data or information in order to "protect the waste of the prior cognitive effort of making a decision" (1998, p. 9). Sage (1981) defines the conservatism bias as "the failure to revise estimates as much as they should be revised based on receipt of new significant information" (p. 3.15; see also Hogarth, 1987, p. 218). For example, a weapons program could suffer from this bias by failing to adequately revise budget and schedule estimates as new information regarding increased costs and schedule delays are received. This bias is irrational because the sunk costs of prior cognitive efforts or commitments should not preclude a rational analysis of new information.

The following is a selection of relevant research associated with the conservatism bias. Peterson, Schneider, and Miller (1965) found test subjects inadequately revised their previously assessed subjective probabilities when presented with additional statistical data (p. 523). Phillips and Edwards (1966) concluded "conservatism in the processing of probabilistic information appears to be a pervasive effect" (p. 353). Phillips, Hays & Edwards (1966) echoed this conclusion, and further speculated that conservatism in processing information was "the result of intellectual [cognitive], not motivational, deficiencies' (p. 17). DuCharme (1970) found the probabilistic conservatism bias to be most prevalent when subjects were asked to assess subjective probabilities of large numbers (p. 74). Fischhoff and Beyth-Marom (1983) summarized "subjects' confidence in the apparently correct hypothesis did not increase as quickly as the accumulating evidence indicated that it should" (p. 248).

6. Control

Arnott (1998) summarizes the control bias (a.k.a. illusion of control) as follows: "A poor decision may lead to a good outcome inducing a false feeling of control over the judgement situation" (p. 9). According to Kahneman (2011), decision makers often underestimate the impact that chance has on events and outcomes (p.14). Arnott (1998) further elaborates that a control bias occurs when "subjective probabilities of an event are systematically assessed to be higher than the relevant objective probabilities" (p. 9), and can be triggered by rigorous planning or even thinking about an event. Using the cognate, illusion of control, Sage (1981) states: "A good outcome in a chance situation may well have resulted from a poor decision. The decisionmaker may assume a feeling of control over events that is not reasonable" (p. 3.17). The control bias is irrational because an individual's degree of confidence in a probabilistic and/or chance event should not exceed the objective known probabilities of that event.

The following is a selection of relevant research associated with the control bias. In a series of studies, Langer (1975) found test participants exhibited the illusion of control bias, which Langer defined as "an expectancy of a personal success probability inappropriately higher than the objective probability would warrant" (p. 311). Langer found the illusion of control bias to be most prevalent in conditions where a chance task/ environment is similar to a skill task/environment; and can be exacerbated by increasing competition among participants, participant choice or involvement, or participants' familiarity with the task (Langer, 1975). In a paper appropriately titled "Heads I Win, Tails It's Chance…" (p. 951), Langer and Roth (1975) were able to induce the control bias with Yale University undergraduates tasked with predicting coin tosses. Koehler, Gibbs, and Hogarth (1994) found this bias to be significantly more prevalent in one-shot gambles versus long-run repeated-event experimental frameworks (p. 190; see also Budescu & Bruderman, 1995), which means that individuals are more susceptible to the control bias when they are faced with unique, low-frequency decision events. DOD weapons programs are likely to suffer from this bias because they deal with very unique decisions under uncertainty, face significant probabilistic/chance events (risk), require rigorous planning,

often compete with other programs for funding, and require decision makers to have a high level of involvement when making decisions.

7. Desire

Arnott (1998) summarizes the desire bias (a.k.a. wishful thinking, value bias, & outcome bias) as follows: "The probability of desired outcomes may be assessed to be greater than actually warrants" (p. 10; see also Schwenk, 1988, p. 44; Carter et al., 2007, p. 638). Success is often overestimated even though a decision maker may have access to information telling them otherwise (Arnott, 1998, 2006). Hogarth (1987) defines this bias as wishful thinking, stating "People's preferences for outcomes of events affect their assessment of the events" (p. 221). In an analysis of 3,500 predictions made by 400 subjects, Mcgregor (1938) found that subjects' predictions were influenced by "the importance that the predictor attributes to the occurrence of the particular event (i.e., the degree to which he believes his own welfare, pride, or ideals will be affected by the event)" (p. 203; as cited in Olsen, 1997). Budescu and Bruderman (1995) found that test subjects consistently demonstrated an outcome desirability bias, with little variance between desired outcomes that were framed as gains or losses. Additionally, while they determined the presence of the desire bias to be highly correlated with the illusion of control (control) bias, they determined that the desire bias was still present in experiments designed to eliminate the influence of the control bias (p. 123). The desire bias is irrational because a decision maker's desire for a specific outcome does not alter the objective probabilities associated with that outcome.

The following is a selection of relevant research associated with the desire bias. In two studies involving professionally certified investment managers from the U.S. and Taiwan, Olsen (1997) found these professionals demonstrated a statistically significant desirability bias when forecasting probabilities. Olsen's findings indicate experts are susceptible to the desire bias, and therefore, it is likely that trained acquisition professionals could be subject to this bias as well. For example, if a weapons program experiences significant schedule delays, decision makers may allow production to begin concurrent with testing. Such a decision would likely have been influenced by the desire bias if

concurrent testing/production was not originally determined to be an advisable course of action. This is because the desire to catch-up the schedule should not subsequently alter the logic underlying the original decision.

While the desire bias is considered by many researchers to be cognitive in nature, Montibeller and Winterfeldt (2015) classify it as a motivational bias. However, because most research into decision biases has focused on cognitive rather than motivational factors, there currently is no clear consensus regarding the role that motivational factors play in this bias (Montibeller & Winterfeldt, 2015, p. 1230). As detailed in Chapter I, for a bias where there is no clear consensus regarding whether a decision bias is purely cognitive, we have highlighted the ambiguity and recommend further study.

8. Escalation

Arnott (1998) summarizes the escalation bias (a.k.a. non rational escalation of commitment, commitment, & entrapment) as follows: “Often decision makers commit to follow or escalate a previous unsatisfactory course of action” (p. 11). Using the term, commitment, Carter et al. (2007) describes the phenomenon as follows: “Once decision makers make a commitment to a person or course of conduct, they may consistently adhere to that commitment eve if later confronted with facts suggesting that the commitment is a bad choice” (p. 636). Lastly, Drummond (1994) succinctly defines the escalation bias as “irrational persistence” (p. 51). This bias is commonly described as throwing good money after bad. Sunk costs such as time, money, or effort are the same whether or not you continue with the course of action, so these costs should be irrelevant to an assessment of a present decision (Northcraft & Wolf, 1984). However, decision makers often exhibit an irrational tendency to continue supporting a previous decision, even when the facts or data the decision was based on have changed. A weapons program could suffer from this bias if decision makers decide to continue with a program that—due to either changing requirements or performance shortfalls—is no longer expected to support the required warfighter capability. Unless the “costs of abandonment, or non-escalation, outweigh the benefits” (Arnott, 1998, p. 11), the escalation bias is considered irrational because sunk costs should not be a factor in deciding whether to continue with a course of action.

The following is a selection of relevant research associated with the escalation bias. Arnott (1998) describes the escalation bias as a meta-bias, where it is likely to result from a combination of the confirmation, adjustment, framing, and success cognitive biases; and motivational decision biases. Staw and Ross (1978) found that test subjects committed the most resources in a fictional scenario when their previous decision resulted in failure versus when their previous decision resulted in a positive outcome. They also found that test subjects committed the most resources when an exogenous (external) reason for the failure was presented to test subjects (Staw & Ross, 1978; see also Staw, 1976, 1981). Drummond (1994) states that "a major cause of escalation is thought to be information-processing bias [i.e., cognitive]" (p. 50). However, her study findings also speculated that other factors such social and political pressure, organizational culture, power dynamics, and visibility of actors may also cause escalation (Drummond, 1994).

Beeler and Hunton (1997) found that test subject were more likely to exhibit the escalation bias when their original decision (i.e., allocations for a fictional stock portfolio) was announced publicly. They also found that those who were incentivized for their performance were more likely to exhibit the escalation bias than those that were paid a flat fee or not paid at all. Lastly, they found those that exhibited the escalation bias were more likely to increase their search for information supporting their prior decision (retrospective information), and were less likely to seek information about the decision at hand (prospective information) (Beeler & Hunton, 1997). (See also Brockner & Rubin, 1985; Schwenk, 1986; Teger, 1980).

While the escalation bias is broadly considered to be cognitive in nature, Bazerman qualified that the escalation bias can be influenced by motivational factors to some extent (1990, 1998; as cited by Arnott, 1998). However, there currently is no clear consensus regarding the role that motivational factors play in this bias. As detailed in Chapter I, given the lack of consensus regarding whether this decision bias is purely cognitive, we have highlighted the ambiguity and recommend further study.

9. Hindsight

Arnott (1998) summarizes the hindsight bias as follows: “In retrospect the degree to which an event would have been predicted is usually overestimated.” (p. 14; see also Hogarth, 1987, p. 222). This bias is most frequently aligned with the phrase “I knew it all along.” It is the inclination, after an event has occurred, to see the event as having been predictable when there has been little to no basis for predicting it. This is why stock market pundits are so adept at explaining the cause of market swings after-the-fact, but are poor at accurately predicting such movements beforehand. The hindsight bias results in more confident decision makers, but reduces these individuals’ ability to learn from past mistakes (Arnott, 1998). For example, a program manager could exhibit the hindsight bias if he/she evaluates poor outcomes from similar programs, and attributes these outcomes to obviously poor decisions that he/she would not have made under similar circumstances. The hindsight bias is an especially important cognitive bias for acquisition reformers to mitigate since acquisition reform efforts have failed to solve the same fundamental problems over the past 60 years (Fox, 2009, p. 35). In other words, if DOD acquisition reform efforts have failed to learn from the mistakes of the past time and time again, then the hindsight bias may something to do with it. Arnott (1998) also indicated that the hindsight bias is likely interrelated with the control bias and the overconfidence bias (See also Langer & Roth, 1975; Fischoff et al., 1977). The hindsight bias is irrational since knowledge of an outcome of an event should not affect the objective predictability of the event.

The following is a selection of relevant research associated with the hindsight bias. Fischhoff and Byeth (1975) found that judges presented with the outcome of an event were disproportionately confident in their ability to have predicted the event than judges who lacked knowledge of the outcome (See also Fischoff, 1982). Additionally, Fischoff (1977) found the hindsight bias to have a robust influence on subjects’ responses, even when subjects were explicitly warned about the influence of the hindsight bias. He concluded that the processes underlying the hindsight bias “are so natural and immediate that people don’t appreciate the effect that hearing the answer has had on their perceptions … Even when told to do so, it is evidently extremely difficult to de-process so important a bit of

information as the right answer" (Fischoff, 1977, p. 356). Next, Connolly and Bukszar (1990) tested whether the hindsight bias was driven by self-flattery (motivational) or cognitive error. They concluded that "cognitive factors are the primary cause of hindsight effects" (p. 209), and that "motivations such as self-flattery or self-presentation are not central to [inducing the hindsight bias]" (Connolly & Bukszar, 1990, p. 208). Next, Ofir & Mazursky (1997) concluded the following reaction framework for the hindsight bias: "When the outcome is relatively unsurprising, the 'I knew it all along' reaction is posited… Conversely, when the outcome is highly surprising, an 'I could not have expected it' reaction results" (p. 57; see also Mazursky and Ofir, 1997). Finally, in a statement that seems to have been written with defense acquisition participants in mind, Kahneman (2011) notes that "because adherence to standard operating procedures is difficult to second-guess, decision makers who expect to have their decisions scrutinized with hindsight are driven to bureaucratic solutions—and to an extreme reluctance to take risks" (pp. 204). (See also Buchman, 1985; Bazerman, 1990, 1998)

10. Overconfidence

Arnott (1998) summarizes the overconfidence bias (a.k.a. planning fallacy & Dunning-Kruger effect) as follows: "The ability to answer difficult or novel questions is often over-estimated" (p. 16). Kahneman (2011) defines a related phenomenon, the planning fallacy, as when plans and forecasts "are unrealistically close to best-case scenarios," and "could be improved by consulting the statistics of similar cases" (p. 250). Referring to the phenomenon as the Dunning-Kruger effect, Dunning (2005) consistently found that research subjects deemed most incompetent in terms of skill or knowledge were the least aware of these shortcomings; and were most likely to overestimate their knowledge or ability. Sage (1981) states "People generally ascribe more credibility to data than is warranted and hence overestimate the probability of success merely due to the presence of an abundance of data. The greater the amount of data, the more confident the person is in the accuracy of the data" (p. 3.18; see also Carter et al., 2007, p. 640). For example, a weapons program could suffer from this bias if decision makers rely upon cost and schedule estimates that are based upon a best case scenario and/or fail to take into account historical cost/schedule overruns for similar programs. This bias is irrational since

the level of one's confidence should take into account one's lack of knowledge, data, or experience regarding a novel task or question, and actively seek disconfirming evidence rather than confirming evidence.

The following is a selection of relevant research associated with the overconfidence bias. Oskamp (1965) evaluated a group of psychologists, and found that while their confidence level increased significantly as they received additional information about a case, there was not a correlating increase in the accuracy of their judgments. See also Howell's (1972) findings, relating to the overconfidence bias, in the discussion of the success bias in this Sub-Section. After conducting a series of experiments, Fischhoff, Slovic, and Lichtenstein (1977) concluded the following: "These five experiments have shown people to be wrong too often when they are certain that they are right" (p. 561). They found the overconfidence bias to be rather robust, arising in a variety of questions, study formats, and test subjects; and when subjects were incentivized with real money to be accurate (Fischhoff et al., 1977). Koriat, Lichtenstein, and Fischhoff (1980) describe the confidence assessment task underlying the overconfidence bias as having two cognitive stages: 1) searching one's knowledge for an answer, and 2) assessing one's confidence in the correctness of that answer. Within these two stages, Koriat et al. (1980) found that subjects systematically favored "positive rather than negative evidence (i.e., reasons for over reasons against) (p. 116) in the first cognitive stage; and that subjects systematically "[disregarded] evidence inconsistent with (contradictory to) the chosen answer (p. 117). Koriat et al. (1980) suggested that the presence of this bias could be mitigated by reframing the instructions/questions to force test subjects to consider negative/contradictory evidence, which indicates a bias that is cognitive in nature. The overconfidence bias is likely interrelated with or the result of a combination of the anchoring and adjustment, confirmation, hindsight, recall, and similarity cognitive biases; and motivational biases (Russo & Schoemaker, 1992; as cited by Arnott, 1998). Kahneman (2011) also notes that the overconfidence bias "is fed by the illusory certainty of hindsight" (p. 14).

While the overconfidence bias is broadly considered to be cognitive in nature, Montibeller and Winterfeldt (2015) classify it as a motivational bias. However, since most research into decision biases has focused on cognitive rather than motivational factors, there

currently is no clear consensus regarding the role that motivational factors play in this bias (Montibeller & Winterfeldt, 2015, p. 1230). As detailed in Chapter I, for a bias where there is no clear consensus regarding whether a decision bias is purely cognitive, we have highlighted the ambiguity and recommend further study.

In terms of our research, the overconfidence bias is the 800-pound gorilla in the room. Based on our literature review and the results of our analysis, the overconfidence bias appears to most prevalently influence deviations from sound acquisition practices; but is the most complex in terms of its' underlying psychological processes, and relation and/or similarity to other decision biases. Also, since there are compelling yet conflicting research findings relating to whether the overconfidence is a cognitive or a motivational decision bias, we speculate it likely results from a mixture of both cognitive and motivational factors.

11. Reference

Arnott (1998) summarizes the reference bias as follows: "The establishment of a reference point, or anchor can be a random or distorted act" (p. 17; see also Carter et al., 2007, p. 641). According to Arnott, this bias is closely related to the anchoring and adjustment bias, but is associated with the selection of a poor reference point (anchor), rather than an insufficient adjustment from the anchor (1998; see also Arnott, 2006). In situations where there is uncertainty, people tend to make assessments by starting from a specific known reference point, and then adjusting that assessment appropriately. Sage (1981) states "People normally perceive and evaluate stimuli in accordance with their present and past experiential level for the stimuli. They sense a reference level in accordance with past experience" (p. 3.19). This approach requires the reference point to have a valid connection to the uncertainty. For instance, the Federal Government often uses historical pricing as a reference point when determining whether a proposed price is fair and reasonable. However, in longstanding sole-source procurement environments, using historical pricing as a reference point would likely result in an inaccurate Government estimate. If the establishment of a reference point is capricious or is somehow biased, judgements adjusting from this reference point will consequently be negatively affected (Arnott, 1998, 2006; Sage, 1981; see also Bazerman, 1990, 1998; Tversky & Kahneman, 1974). Similar to the anchoring

and adjustment bias, while the use of anchors/reference points in making decisions under uncertainty is not inherently irrational, selecting invalid anchors/reference points that do not have a "valid connection to the uncertainty" (Sage, 1981, p. 3.19) is not rational.

12. Selectivity

Arnott (1998) summarizes the selectivity bias (a.k.a. selective perception & desire for self-fulfilling prophecies) as follows: "Expectation of the nature of an event can bias what information is thought relevant" (p. 20; see also Carter et al., 2007, p. 641). Sage (1981) describes a similar phenomenon, desire for self-fulfilling prophecies, as follows: "The decisionmaker values a certain outcome, interpretation, or conclusion and acquires and analyzes only information that supports this conclusion" (p. 3.16). Schwenk (1988) defines selective perception as follows: "Expectations may bias observations of variables relevant to strategy" (p. 44). Bruner and Postman (1949) found test subjects had difficulty correctly identifying playing cards that had been modified to be incongruous (ex. black three of hearts, red six of spades, black ace of diamonds, etc.) with the subjects' expectations. Concluding that their test subjects' propensity to draw broad conclusions from small sample sets was a cognitive bias rather than a motivational bias, Tversky and Kahneman (1971) state:

> The true believer in the law of small numbers commits his multitude of sins against the logic of statistical inference in good faith. The representation hypothesis describes a cognitive or perceptual bias, which operates regardless of motivational factors. … His intuitive expectations are governed by a consistent misperception of the world rather than by opportunistic wishful thinking. (p. 110)

The selectivity bias is irrational because the systematic exclusion or omission of data/ information contrary to one's expectations does not change reality. Rather, a rational statistical approach actively seeks disconfirming information to test a null hypothesis (See also Kahneman & Tversky, 1972, 1973; Tversky & Kahneman, 1974).

The following is a selection of relevant research associated with the selectivity bias. Ariely (2010) demonstrated the influence of selective perception by offering college students a taste test and subsequent choice between two beers, a commercial brand and a craft brand that had been laced with balsamic vinegar. Ariely found students without knowledge of the

balsamic vinegar preferred the craft brand, but students that knew about the vinegar beforehand preferred the taste of the commercial brand. Ariely also found students that were told afterwards about the vinegar in their chosen beer still preferred their choice of beer, and in subsequent experiments, even added extra vinegar when given the opportunity (Ariely, 2010, pp. 202–208).

The selectivity bias can cause an individual to systematically exclude or dismiss opportunities, data, or feedback that does not fit the individual's expected outcome. For example, if the Air Force is evaluating how a defense capability should be met, it is likely the Air Force would propose an aircraft solution. This propensity brings to mind the famous quote by Abraham Maslow (1966): "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail" (pp. 15–16). Selective perception is especially problematic when individuals from several areas of expertise, departments, and/or backgrounds all work on the same problem, but approach the problem with widely differing selective perceptions (Dearborn & Simon, 1958; see also Cyert, Dill, & March, 1958). Dearborn & Simon found that executives perceived "those aspects of a situation that relate specifically to and goals of his department" (1958, p. 142). A weapons program could suffer from this bias since numerous Defense Acquisition Communities of Practice (CoPs) such as Program Management, Auditing, Systems Engineering, Risk Management, Test and Evaluation, Contracting, etc., all have selective perceptions that are influenced by their own respective CoP's values, best practices, culture, etc.

13. Success

Arnott (1998) summarizes the success bias (a.k.a. fundamental attribution error & success/failure attribution) as follows: "Often failure is associated with poor luck and success with the abilities of the decision maker" (p. 22; see also Carter et al., 2007, p. 642) (See also Sage, 1981, p. 3.17; Hogarth, 1987, p. 642). Arnott elaborates further that the success bias leads a decision maker to attribute successful outcomes to internal factors such as intelligence, decision making prowess, experience, etc.; but to attribute unsuccessful outcomes "to external factors such as unfair competition, weather, timing, and luck" (Arnott, 1998, p. 22; see also Arnott, 2006). The success bias is closely associated with the

overconfidence bias and the control bias (Arnott, 1998). However, Arnott differentiates between the success bias and the control bias, stating that the control bias arises in situations "where poor decision processes have a desirable outcome" (p. 22), whereas the success bias is "a common behaviour pattern of believing that successful decision outcomes are a result of the persons decision making prowess" (Arnott, 1998, p. 22). The success bias is irrational because the logical standards for attributing responsibility for an outcome should remain the same, regardless of the subject under scrutiny or whether the outcome was positive or negative.

The following is a selection of relevant research associated with the success bias. Howell (1972) concluded that, when dealing with "uncertainty arising from their own behavior (internal or skill-derived uncertainty), [test subjects] showed a consistent tendency toward overconfidence" (p. 6; see also Langer & Roth, 1975). Howell found this tendency towards internal overconfidence to be generalizable since it has been confirmed under a broad range of experimental conditions, and for "several very different kinds of behavior" (p. 6). Howell found test subjects were more likely to overestimate unpredictable events that were dependent on the subjects' skill (i.e., dart throwing) versus events that were more obviously out of the subjects' control (i.e., spinning a roulette wheel) (Howell, 1972; see also Ross, 1977). These findings indicate that when decision makers perceive uncertain events to be within their control or largely affected by expertise/skill, they are systematically biased towards being overconfident in their assessments of positive outcomes. Additionally, when confronted with a poor outcome, a decision maker is likely to attribute the outcome to external factors outside his/her control.

Nisbett and Wilson (1977) described what they termed as test subjects' "illusion of introspective awareness." They concluded that after-the-fact, 1) people have significant difficulty assessing why they made a decision, and what internal and external stimuli affected their decision; 2) people may not "interrogate a memory of the cognitive processes that operated on the stimuli" (p. 233), but rather rely upon priori causal theories (pre-established mental models of cause and effect); and 3) instances where subjects accurately assess higher mental processes are "due to the incidentally correct employment of a priori causal theories" (p. 233). In other words, we are poorly equipped to recognize after-the-fact what factors

influenced our decisions, and/or whether decisions were based upon an intuitive (System 1) or a logical/rational (System 2) type process. We are likely unaware of our unawareness. Our memories are not videotapes or transcripts that can be objectively analyzed, but rather are impressions and perceptions that can shift based upon the outcomes of our decisions (Heuer, 1999). The illusion of introspective awareness is a psychological phenomenon that likely plays a significant role in the control bias and the success bias, and indicates that these biases are likely cognitive in nature rather than motivational.

However, while Miller (1976) corroborated the existence of the success bias in his study, he proposed that his findings indicate that ego and self-serving motivational factors, rather than cognitive factors, were largely responsible for the success bias, but indicated that further study is needed to confirm this. As detailed in the preceding discussion, while the success bias is broadly considered to be cognitive in nature, there currently is not a clear consensus for this conclusion (Miller, 1976; see also Montibeller & Winterfeldt, 2015, p. 1233). As detailed in Chapter I, for a bias where there is no clear consensus regarding whether a decision bias is purely cognitive, we have highlighted the ambiguity and recommend further study.

E. MOTIVATIONAL DECISION BIASES

This section will provide an overview of two motivational decision biases we encountered most prevalently in our analysis. For each bias, we provide a brief summary of the bias; an example of how the bias could manifest in a DOD weapon system acquisition environment; and a selection of relevant research (if any), along with any situational indicators and/or conditions where the bias is likely to occur. However, considering the limited scope of this research, the discussion of each bias is limited to a general overview in order to provide the reader with a foundation for the discussion of our findings.

1. Misaligned Perception of Corporate Goals

Lovallo and Sibony (2010) define "Misaligned Perception of Corporate Goals" bias (a.k.a. principal-agent problem) as follows: "Disagreements (often unspoken) about the hierarchy or relative weight of objectives pursued by the organization and about the tradeoffs between them" (p. 15). This bias represents the self-interested motivations that sub-groups

within an organization may exhibit when their interests conflict with the overarching organization. In the context of the defense acquisition environment, what is good for the Government as a whole might not be considered to be a benefit to a particular agency or weapons program. For example, although the Government benefits from cutting wasteful spending and/or reallocating funds to programs deemed to be the highest priority, a program manager might decide to use up funds as quickly as possible to avoid budget reallocations and/or budget cuts. GAO's (1992) description of parochialism falls within this category of motivational biases. Individual service branches exhibit parochialism by developing requirements and narrowly considering alternatives which favor developing weapons within the individual branch's area of responsibility (GAO, 1992, p. 41). Lovallo and Sibony (2010) offer an intuitive argument for the existence of this motivational bias, but offer no empirical evidence or studies to support their assertion. This lack of supporting empirical research is consistent with Montibeller and Winterfeldt's (2015) assertion that most research into decision biases has focused on cognitive rather than motivational decision biases (p. 1230).

2. Strategic Misrepresentation

Jones and Euske (1991) define strategic misrepresentation as the "planned, systematic distortion or misstatement of fact—lying— in response to incentives" (p. 437). This bias results in an organization knowingly understating costs and overstating benefits. Our original DBD did not include strategic misrepresentation, but was added later to better define the incentive-driven behaviors found in our third case study. While strategic misrepresentation is a conscious decision rather than a cognitive or motivational bias, we included it as a motivational bias within our analysis since the behavior is incentive-driven. Although strategic misrepresentation and the overconfidence bias are often closely associated with each other (Flyvbjerg, Skamris Holm, & Buhl, 2005), strategic misrepresentation is differentiated by purposeful and calculated statements and/or omissions that result in misrepresentations of fact to a decision maker. According to Jones and Euske (1991), strategic misrepresentation is a result of intentional planning with the goal of maximizing benefits within a system of "controlled competition for limited resources" (p. 438). Acquisition participants guilty of this bias would justify it as an expected part of the negotiation and argue that many worthwhile projects would never get approved if the true

costs were revealed at the start. Finally, while GAO (1992) stops short of stating these behaviors are intentional, the report comes very close to describing this bias:

> The desire of program sponsors to keep cost estimates as low as possible and to present attractive milestone schedules has encouraged the use of unreasonable assumptions about the pace and magnitude of the technical effort, material costs, production rates, savings from competition, and other factors. (p. 21)

F. SUMMARY

This chapter detailed the relevant literature we reviewed in order to inform our overall analysis, review various decision bias taxonomies necessary to develop our DBD, identify common types of decision biases, and review the literature supporting GAO's incentives narrative. Next, Chapter III details the analysis methodologies and data used to answer our primary and secondary research questions, which ultimately enabled us to achieve our primary and secondary research objectives.

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III. DATA AND ANALYSIS

Chapter II details the literature review we performed to inform our analysis and to develop our DBD. This chapter details our analysis methodologies and data. Section A summarizes the analysis methodologies and data we used to answer the primary and secondary research questions associated with our primary research objective. Section B summarizes the analysis methodologies and data we used to answer the primary and secondary research questions associated with our secondary research objective. Each section explains how the research questions were answered, to include what data was needed, how the data was obtained, and what analysis methodologies were utilized to answer each respective question.

A. PRIMARY RESEARCH OBJECTIVE

To determine whether it is likely that cognitive decision biases significantly contribute to deviations from sound acquisition practices, we evaluated a selection of case studies to determine which (if any) decision biases were likely to have contributed to deviations from sound acquisition practices. To do this, we first compiled a decision bias dictionary (DBD) of well-established cognitive and motivational decision biases, and then used the DBD to code a selection of GAO report transcripts. This section summarizes our analysis methodology and data used to answer these questions.

1. Decision Bias Dictionary

Prior to conducting our analysis, it was necessary to compile a customized DBD of well-established cognitive and motivational decision biases. As introduced in Chapter I and detailed in Chapter II, we ultimately assembled a customized DBD consisting 44 individual biases, divided into 8 bias categories. The dictionary included columns for each bias category, bias name, bias code, bias definition, notes regarding situational indicators and conditions where the bias is likely to occur, and cognates (synonymous, similar, or related decision biases). The information contained within the dictionary was adapted and/ or incorporated verbatim from the decision bias taxonomies detailed in Chapter II (See Arnott, 1998, 2006; Lovallo and Sibony, 2010; Jones & Euske, 1991).

After deciding on the source taxonomies and biases, we assigned unique codes for each bias and category; reviewed and discussed taxonomy descriptions for each decision bias; and added notes within the DBD regarding situational indicators and conditions where certain biases were likely to occur. We began by assigning unique codes for each of the bias categories and individual decision biases listed within the DBD, to allow for efficient coding of our transcripts. Next, to confirm our joint understanding of the DBD, we reviewed and discussed each decision bias within our DBD, including descriptions, examples, cognates, and similar biases within the DBD. We also reviewed the original taxonomies for more detailed information regarding each decision bias, to include in-depth descriptions, examples, cognates, and empirical studies referenced. Informed by this review, we added notes within the DBD regarding situational indicators and conditions where certain biases were likely to occur.

We discussed whether each decision bias was determined by the source taxonomies to be a cognitive or motivational bias, and indicated this assessment within our DBD as follows: "C" (cognitive) or "M" (Motivational). However, while the "Confirmation," "Desire," "Escalation," "Overconfidence," and "Success" biases are categorized as cognitive biases by many researchers/taxonomies and our source taxonomy; we noted there is currently a lack of clear consensus among researchers regarding whether these biases are purely cognitive, purely motivational, or a mixture of two. In these instances, we noted the ambiguity but did not come to a definitive assessment, indicating the ambiguity within our DBD as follows: "C or M".

Table 2 is a condensed version (columns B, C, & E) of our DBD, including all 44 individual biases, and 8 bias categories used for our analysis.

Table 2. Combined Table of Selected Decision Bias Taxonomies

BIAS	CODE	BIAS DESCRIPTION
ADJUSTMENT BIAS CATEGORY*		
Anchoring and Adjustment*	Adj-1	Adjustments from an initial position are usually insufficient
Conservatism*	Adj-2	Often estimates are not revised appropriately on the receipt of significant new data
Reference*	Adj-3	The establishment of a reference point or anchor can be a random or distorted act
Regression*	Adj-4	That events will tend to regress towards the mean on subsequent trials is often not allowed for in judgement
CONFIDENCE CATEGORY*		
Completeness*	Con-1	The perception of an apparently complete or logical data presentation can stop the search for omissions
Confirmation*	Con-2	Often decision-makers seek confirmatory evidence and do not search for disconfirming information
Control*	Con-3	A poor decision may lead to a good outcome, inducing a false feeling of control over the judgement situation. Arises when subjective probabilities of an event are systematically assessed to be higher than the relevant objective probabilities. Rigorous planning can also induce the bias
Desire*	Con-4	The probability of desired outcomes may be inaccurately assessed as being greater
Overconfidence*	Con-5	The ability to solve difficult or novel problems is often overestimated
Redundancy*	Con-6	The more redundant and voluminous the data, the more confidence may be expressed in its accuracy and importance
Selectivity*	Con-7	Expectation of the nature of an event can bias what information is thought to be relevant
Success*	Con-8	Often failure is associated with poor luck, and success with the abilities of the decision-maker
Test*	Con-9	Some aspects and outcomes of choice cannot be tested, leading to unrealistic confidence in judgement

BIAS	CODE	BIAS DESCRIPTION
INTEREST BIAS CATEGORY*		
Misaligned Individual Incentives**	Int-1	Tendency to genuinely (not cynically) hold views or seek outcomes favorable to oneself or one's unit at the expense of the overall interest of the company.
Inappropriate Attachments**	Int-2	Tendency to create emotional attachments to people or elements of the business resulting in misalignment of interests.
Misaligned Perception Of Corporate Goals**	Int-3	Tendency of people to hold conflicting perceptions (often unspoken) about hierarchy or relative weight of and trade-offs between objectives pursued by the company.
Strategic Misrepresentation***	Int-4	A planned, systematic distortion or misstatement of fact (lying) in response to incentives
MEMORY BIAS CATEGORY*		
Hindsight*	Mem-1	In retrospect, the degree to which an event could have been predicted is often overestimated
Imaginability*	Mem-2	An event may be judged more probable if it can be easily imagined
Recall*	Mem-3	An event or class may appear more numerous or frequent if its instances are more easily recalled than other equally probable events
Search*	Mem-4	An event may seem more frequent because of the effectiveness of the search strategy
Similarity*	Mem-5	The likelihood of an event occurring may be judged by the degree of similarity with the class it is perceived to belong to
Testimony*	Mem-6	The inability to recall details of an event may lead to seemingly logical reconstructions that may be inaccurate
PRESENTATION BIAS CATEGORY*		
Framing*	Pres-1	Events framed as either losses or gains may be evaluated differently
Linear*	Pres-2	Decision-makers are often unable to extrapolate a nonlinear growth process
Mode*	Pres-3	The mode and mixture of presentation can influence the perceived value of data
Order*	Pres-4	The first or last item presented may be over weighted in judgement
Scale*	Pres-5	The perceived variability of data can be affected by the scale of the data

BIAS	CODE	BIAS DESCRIPTION
SITUATION BIAS CATEGORY*		
Attenuation*	Si-1	A decision-making situation can be simplified by ignoring or significantly discounting the level of uncertainty
Complexity*	Si-2	Time pressure, information overload, and other environmental factors can increase the perceived complexity of a task
Escalation*	Si-3	Often decision-makers commit to follow or escalate a previous unsatisfactory course of action
Habit*	Si-4	An alternative may be chosen only because it was used before
Inconsistency*	Si-5	Often a consistent judgement strategy is not applied to an identical repetitive set of cases
Rule*	Si-6	The wrong decision rule may be used
SOCIAL BIAS CATEGORY		
Groupthink**	Soc-1	Tendency to strive for consensus at the cost of a realistic appraisal of alternative courses of action.
Sunflower Management**	Soc-2	Tendency for groups to align with the views of their leaders, whether expressed or assumed.
STATISTICAL BIAS CATEGORY*		
Base rate*	Stat-1	Base rate data tends to be ignored when other data are available
Chance*	Stat-2	A sequence of random events can be mistaken for an essential characteristic of a process
Conjunction*	Stat-3	Probability is often overestimated in compound conjunctive problems
Correlation*	Stat-4	The probability of two events occurring together can be overestimated if they have co-occurred in the past
Disjunction*	Stat-5	Probability is often underestimated in compound disjunctive problems
Sample*	Stat-6	The size of a sample is often ignored in judging its predictive power
Subset*	Stat-7	A conjunction or subset is often judged more probable than its set

*Adapted from Arnott (2006, pp. 60–61)

** Adapted from Lovallo and Sibony (2010, p. 15)

***Adapted from Jones and Euske (1991, p. 1).)

2. Transcript Coding Methodology

First, we reviewed the case study to identify deviations from sound acquisition practices and/or a normative principle, or identify a situation/decision that was likely susceptible to decision biases. Once identified, these passages were highlighted for further review for evidence of a decision bias. Since we used GAO reports on Major Defense Acquisition Programs (MDAPs) as our case study transcripts, we often had very specific assessments from GAO regarding whether some decisions were considered to deviate from sound acquisition practices. We also reviewed the case to identify situations/decisions that were considered susceptible to decision biases. We identified these by referring to the definitions and situational indicators within our DBD. We also examined any charts or graphs within the case study to identify any situational indicators for decision biases, especially presentation biases. For instance, we might assess the "Framing" bias if the information displayed could be framed as either a gain or a loss.

Second, we examined the highlighted passages to assess which (if any) decision bias could have influenced the decision/situation, and we assigned one or more bias codes. For instances where the DBD's concise definitions were insufficient to make an assessment, we referred back to the expanded bias descriptions within the source taxonomy. Since some decision biases within our DBD have overlapping definitions and shared effects, as detailed in Chapter II, we sometimes had to choose which decision bias best fit the situation. However, in every such instance, the choice was between two similar cognitive biases. There were numerous passages where we identified more than one possible decision bias for the same situation/decision, but this does not mean that all or even any of the assessed biases influenced the decision. Since it was impossible to definitively confirm which decision bias influenced a decision; we assessed which bias(es) were most likely to have influenced the decision, and/or which bias(es) the decision was most susceptible to, based on the context of the situation/decision. This approach is supported by Heuer (1999), who states "When psychological experiments reveal the existence of a bias, this does not mean that every judgement by every individual person will be biased. It means that in any group of people, the bias will exist to a greater or lesser degree in most judgements made by most of the group" (p. 112). Therefore, our goal was

to come to a reasonable subjective assessment of what types of decision biases were likely to have influenced the decision, viewing the passage through the lens of the HBP perspective rather than RCM perspective.

3. Case Study Sources and Selection Considerations

GAO reports were chosen as the data source for case study transcripts for several reasons. First, reviewing GAO reports provided an excellent contrast between GAO's incentives-based perspective and the HBP perspective to assess deviations from sound acquisition practices. Next, GAO is widely considered to be a respected and objective authority with regard to assessing DOD acquisition programs, using consistent research methodologies and practices. Additionally, since GAO is used extensively by Congress to provide assessments/recommendations regarding DOD acquisition programs, GAO reports provide a consistently high level of accuracy and access to pertinent information/data. Finally, reviewing GAO report transcripts allowed us to apply a consistent normative standard (i.e. KBA approach) for identifying deviations from sound acquisition practices in our analysis. This consistency allowed us to rely upon GAO's assessments regarding whether decisions identified within each case study were identified as deviations from sound acquisition practices. However, as detailed in Chapter I, we did view these assessments in light of the DOD and/or Agency responses to GAO's findings included at the end of each report.

We reviewed several GAO MDAP reports as potential candidates for our analysis. Our review considered a wide range of GAO reports on DOD MDAPs, to include joint programs and Army, Navy, Marine Corps, and Air Force programs in various stages of the acquisition cycle. We considered programs with positive and/or negative acquisition outcomes, but we did not select case studies with the goal of determining the relative influence or impact of assessed decision biases on acquisition outcomes. Our analysis focused on identifying decision biases associated with deviations from sound acquisition practices, regardless of acquisition outcomes. Accordingly, we specifically selected reports where GAO identified multiple deviations from sound acquisition practices, and where GAO provided detailed background/context into the decisions underlying these deviations.

We chose GAO reports on the Navy's Ford-Class Aircraft Carrier and Littoral Combat Ship and Frigate (LCS) programs because GAO has specifically cited the incentives narrative to explain poor acquisition outcomes within these programs (GAO, 2015c; GAO, 2016b). We chose to review these two cases to provides a unique contrast between GAO's incentives-based perspective and the HBP perspective. Finally, while we preferred reports that were relatively recent, we selected older GAO reports where GAO provided greater detail/context into identified deviations from sound acquisition practices. Based on the above criteria, two Navy programs, one Marine program, one Air Force program, and one joint program were ultimately selected for analysis, and are detailed as follows:

(1) Littoral Combat Ship (LCS) and Frigate (GAO, 2016b)

(2) Amphibious Combat Vehicle (ACV) (GAO, 2018b)

(3) Ford-Class Aircraft Carrier, CVN 78 (GAO, 2017b)

(4) F-22A (GAO, 2012a)

(5) Joint Strike Fighter (JSF) (GAO, 2009)

4. Analysis

During the analysis phase, two people independently coded our initial transcripts and validated/updated our coding methodologies and DBD accordingly, coded the remaining transcripts, and compiled/analyzed our findings.

First, in order to validate the efficacy of the DBD and the precision of both transcript coders, we coded our first three case studies independently. Each reviewer separately highlighted passages within the transcript that indicated a deviation from sound acquisition practices. Next, using the comments feature within the PDF software, each reviewer inserted the assessed decision bias code, and in some cases, additional notes regarding the reviewer's rationale. After each of the three initial cases, we compared our results, assessed the root cause(s) of any coding discrepancies (if any), and revised our transcript coding methodologies and DBD accordingly. We also reviewed our assessed decision biases to ensure we did not double count biases where the same event/decision was discussed in multiple passages. In most instances, both reviewers highlighted the same

passages indicating a deviation from sound acquisition practices. In the few instance where one of the reviewers highlighted a specific passage and the other did not, we discussed each other's rationale and agreed whether the passage in question would remain as part of the overall analysis. Coding assignments by each of the reviewers were also discussed. While the majority of independent coding assignments were identical, some differed due to individual interpretations of the text presented in the transcript. In such cases, both viewpoints were discussed, notations were made in those passages, and a final coding assignment was agreed upon. These discussions aided both reviewers in gaining a better understanding of the DBD's biases descriptions, and to improve the DBD itself. These discussions also enabled us to establish consistent coding assignments for commonly cited decisions and/or situations encountered within and/or among the assessed case studies.

After completing this process, we calculated our inter-rater reliability to determine the reliability of our rating scheme and methodologies. To do this, we evaluated the variances between our independent coding decisions for our third case study, Ford-Class Aircraft Carrier, CVN 78. We found that out of 133 separate instances, our independent assessments varied only 10 times (7.52%). This figure includes situations where either one of us assessed a bias for a decision/situation where the other one did not, or we had different assessed biases for the same decision/situation. Therefore, our validation efforts for the CVN 78 case resulted in an overall rater-reliability percentage of 92.48%.

After reviewing and validating our results for the first three cases, we determined that two additional case studies would be more than sufficient to provide an illustrative view of the HBP perspective. Subsequently, one reviewer coded the remaining two transcripts, and compiled our combined findings into a spreadsheet. In Chapter IV, we present a table of assessed biases for our overall analysis and within the discussion of each case study's findings. These tables list each assessed bias by frequency of occurrence, but are not presented as a definitive/comprehensive ranking. Additionally, because the assessed case study transcripts varied significantly in length, the overall number of assessed biases was not necessarily indicative of the program's susceptibility to decision biases. In addition to noting the frequency and distribution of the assessed decision biases, we also sought to make tentative conclusions regarding specific circumstances (e.g., concurrency

strategies) and common themes we encountered within and among the assessed case studies. Finally, based upon the results of our analysis and literature review, we made conclusions and recommendations, as detailed in the Chapter V.

B. SECONDARY RESEARCH OBJECTIVE

In order to achieve our secondary research objective, we needed to assess whether GAO's incentives narrative was well-founded and conclusive (primary research question 1b). To do this, we reviewed relevant GAO reports and major acquisition reform studies' findings concerning defense acquisition culture and incentives to examine the fundamental assumptions, historical development, and empirical research/critical reviews supporting GAO's incentives narrative (secondary research question 2b). This literature review is detailed in Chapter II, and our findings are detailed in Chapter IV.

C. SUMMARY

This chapter detailed the analysis methodologies and data used to answer our primary and secondary research questions, which ultimately enabled us to achieve our primary and secondary research objectives. Next, Chapter IV discusses our findings and the results of our analysis.

IV. FINDINGS/RESULTS

In this chapter, we present the results of our analysis, which strongly support our expectation that both cognitive and motivational decision biases are likely to have contributed to deviations from sound acquisition practices in the coded case studies. First, we present our primary research objective findings, starting with a summary of results for our overall analysis. Next, we detail our findings for each case study; including a case overview, a table of assessed biases, examples and discussions of a selection of assessed biases, and figures and charts depicting our findings. Lastly, we present our findings related to our secondary research objective.

A. PRIMARY RESEARCH FINDINGS

This section will present a summary of results for our overall analysis, followed by a summary of results for each individual case study. An overview of each case study is provided to support the discussion of the selected examples for each case study. Each case study includes a discussion of a selection of assessed individual biases and/or groupings of decision biases encountered within our analysis. This discussion includes the percentage of passages where the bias cited, at least one example passage where the bias was assessed, and the rationale for our assessment. Also, if applicable, we identify any other unique circumstances/considerations and/or common themes associated with the identified bias. Lastly, some of the assessed biases are presented as a group of biases because they share the same example cited passage and/or they share a common theme in the context of the case study. However, these bias groupings are coincidental, and do not necessarily reflect a fundamental linkage or consistent co-occurrence within our findings. Our overall analysis summary and each case study summary includes figures and charts that graphically represent our findings.

Our overall analysis identified 347 discrete instances where a decision bias was evident. Table 3 provides a summary of the coded decision biases, which are ranked based on number of occurrences. Figure 4 depicts the percentage that each bias category was

represented for all of the assessed decision biases. Each bias category within the pie chart is the same color as the corresponding category within our DBD, detailed in Chapter III.

Table 3. Identified Decision Biases

Bias	**Assigned Bias Code**	**Number of Occurrences**
Attenuation	Si-1	51
Overconfidence	Con-5	42
Hindsight	Mem-1	28
Anchoring/Adjustment	Adj-1	25
Control	Con-3	25
Conjunction	Stat-3	25
Misaligned Corp Goals	Int-3	18
Escalation	Si-3	16
Conservatism	Adj-2	14
Complexity	Si-2	14
Desire	Con-4	10
Selectivity	Con-7	10
Reference	Adj-3	9
Strat Misrepresentation	Int-4	7
Success	Con-8	6
Completeness	Con-1	5
Confirmation	Con-2	5
Test	Con-9	5
Framing	Pres-1	5
Disjunction	Stat-5	5
Habit	Si-4	4
Regression	Adj-4	3
Imaginability	Mem-2	2
Scale	Pres-5	2
Rule	Si-6	2
Base rate	Stat-1	2
Correlation	Stat-4	2
Inappropriate Attachments	Int-2	1
Similarity	Mem-5	1
Linear	Pres-2	1
Inconsistency	Si-5	1
Chance	Stat-2	1

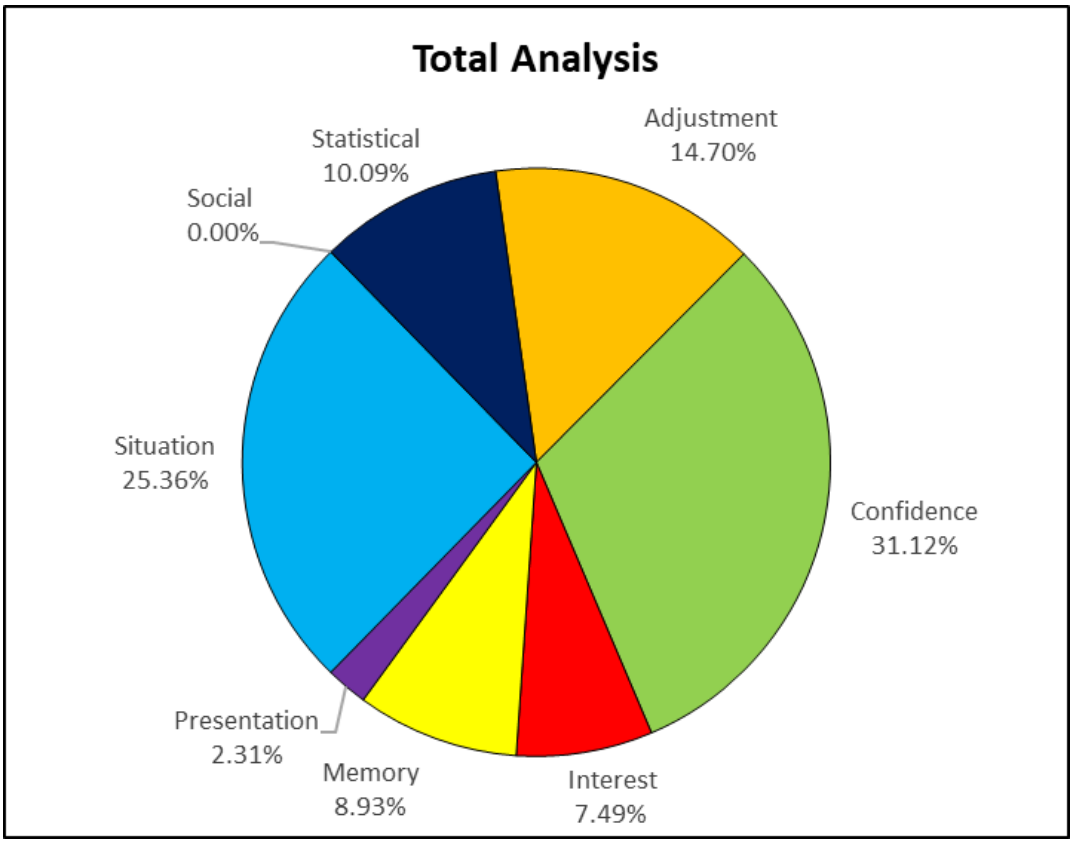

Figure 4. Categories of Identified Decision Biases

Figure 5 depicts the percentage that each individual bias was assessed for the overall analysis. The pie chart graphically represents the incidence of every decision bias assessed for the case study; and is labeled with the bias category abbreviation, bias name, and number of times assessed.

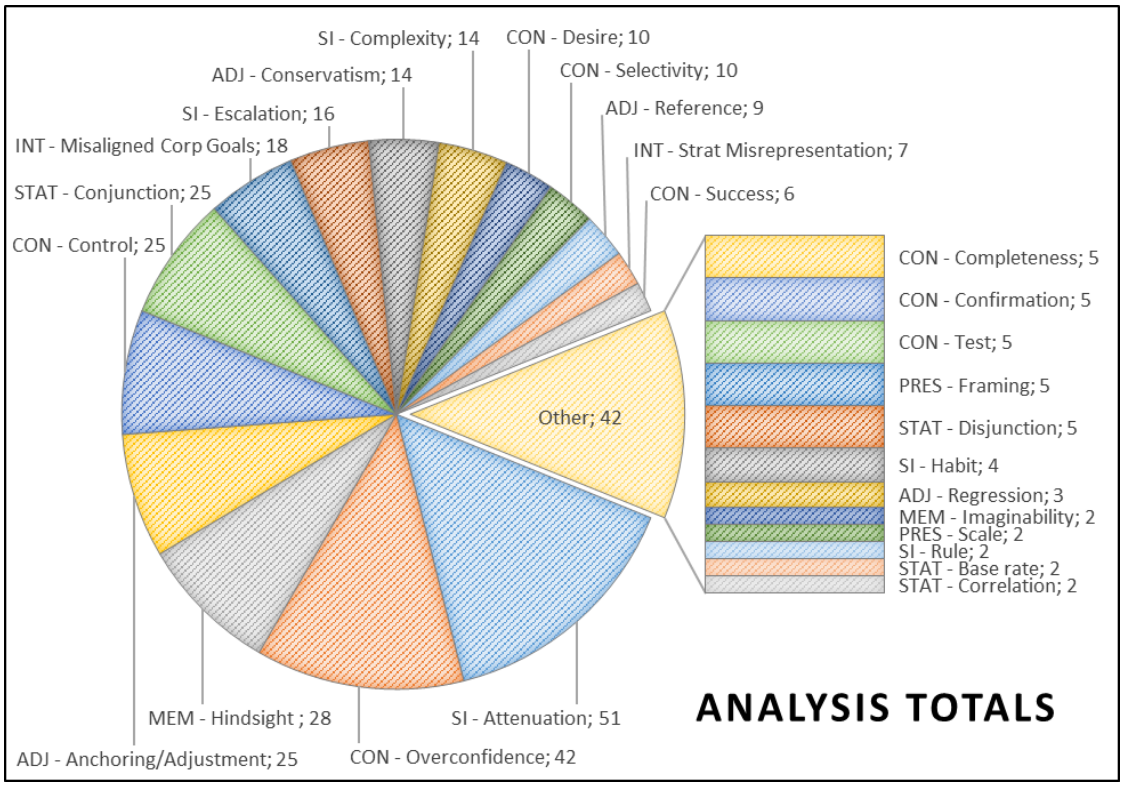

Figure 5. Assessed Decision Biases

Figure 6 provides a word cloud illustration that graphically depicts the variety and frequency of the assessed decision biases within the case study. The size and color of the assessed biases are depicted relative to the frequency they were assessed, with bigger/ darker words indicating a higher frequency of assessment. However, the placement of the words within the word cloud are random.

Figure 6. Decision Bias Word Cloud Visualization—Total Analysis

1. Primary Research Findings: Littoral Combat Ship and Frigate (GAO, 2016b)

a. Case Overview

The Littoral Combat Ship and Frigate (LCS) program has been the subject of numerous GAO reports since its inception. A synopsis of many of these reports were included in testimony presented before the Committee on Armed Services, U.S. Senate by Paul L. Francis (Managing Director of Acquisition and Sourcing Management) of GAO. The testimony transcript, delivered 1 Dec 2016, covered the LCS program's acquisition history, business case, key risks in the Navy's plans for program, and remaining oversight opportunities in the face of pending critical acquisition decisions. The ship designs were originally "two different prototype ships adapted from commercial designs" (Highlights

Page), identified as the Freedom and Independence variants (a.k.a. seaframes). The ships, once built, were originally planned to be sea tested in order to determine the final design. However, GAO noted that these initial plans "were abandoned early in favor of an acquisition approach that committed to [procuring] numerous ships before proving their capabilities" (Highlights Page); and cautioned that "making these commitments now could make it more difficult to make decisions in the future to reduce or delay the program should that be warranted" (Highlights Page). GAO also detailed how persistent problems with corrosion, propulsion systems, and the Mission Modules (Mine Countermeasures [MCMs], surface warfare [SUW], and antisubmarine warfare [ASW]) had resulted in large overall program cost overruns, significant schedule delays, ships delivered without contracted capabilities, and a significant reduction in the number of ships originally planned for procurement (GAO, 2016b). GAO also found the Navy's vision for LCS had changed significantly. The original program quantity had taken a sharp decrease from 55 to 40 seaframes. Initial Operational Capability (IOC) slipped from the original date of 2007 to only partial capabilities delivered in 2013. The Freedom variant could meet sprint speed, but not the range parameters; and the Independent variant did not meet sprint speed, but met the range parameters. While the program initially called for an IOC of the three Mission Modules by 2010; only one of the modules had met IOC in 2015, with the remaining two planned for 2020, but with a lowered level of performance (GAO, 2016b).

b. Findings

Our analysis of the LCS case identified 54 discrete instances where a decision bias was evident. Table 4 summarizes the coded decision biases, which are ranked based on number of occurrences. Figure 7 depicts the percentage that each bias category was represented for all of the assessed decision biases. Each bias category within the pie chart is the same color as the corresponding category within our DBD, detailed in Chapter III.

Table 4. LCS Case—Identified Decision Biases

Bias	Assigned Bias Code	Number of Occurrences
Overconfidence	Con-5	8
Attenuation	Si-1	8
Misaligned Perception of Corporate Goals	Int-3	5
Hindsight	Mem-1	4
Conjunction	Stat-3	3
Regression	Adj-4	3
Complexity	Si-2	3
Escalation	Si-3	3
Habit	Si-4	3
Rule	Si-6	2
Confirmation	Con-2	2
Anchoring and Adjustment	Adj-1	2
Reference	Adj-3	1
Conservatism	Adj-2	1
Control	Con-3	1
Selectivity	Con-7	1
Test	Con-9	1
Strategic Misrepresentation	Int-4	1
Framing	Pres-1	1
Base Rate	Stat-1	1

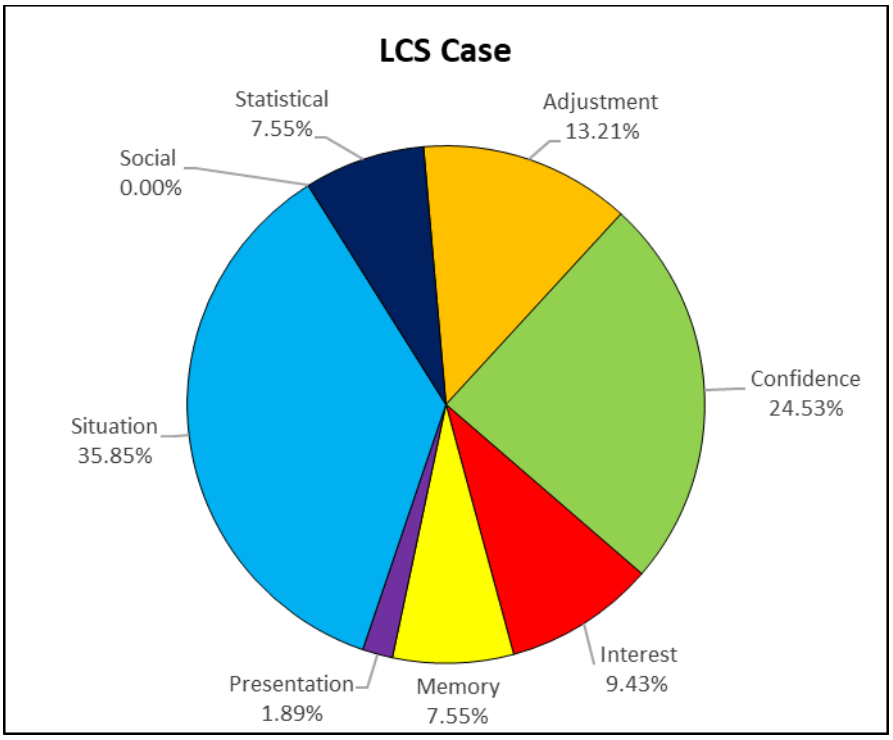

Figure 7. Categories of Identified Decision Biases—LCS Case

Figure 8 depicts the percentage that each individual bias was assessed within the case study. The pie chart graphically represents the incidence of every decision bias assessed for the case study; and is labeled with the bias category abbreviation, bias name, and number of times assessed.

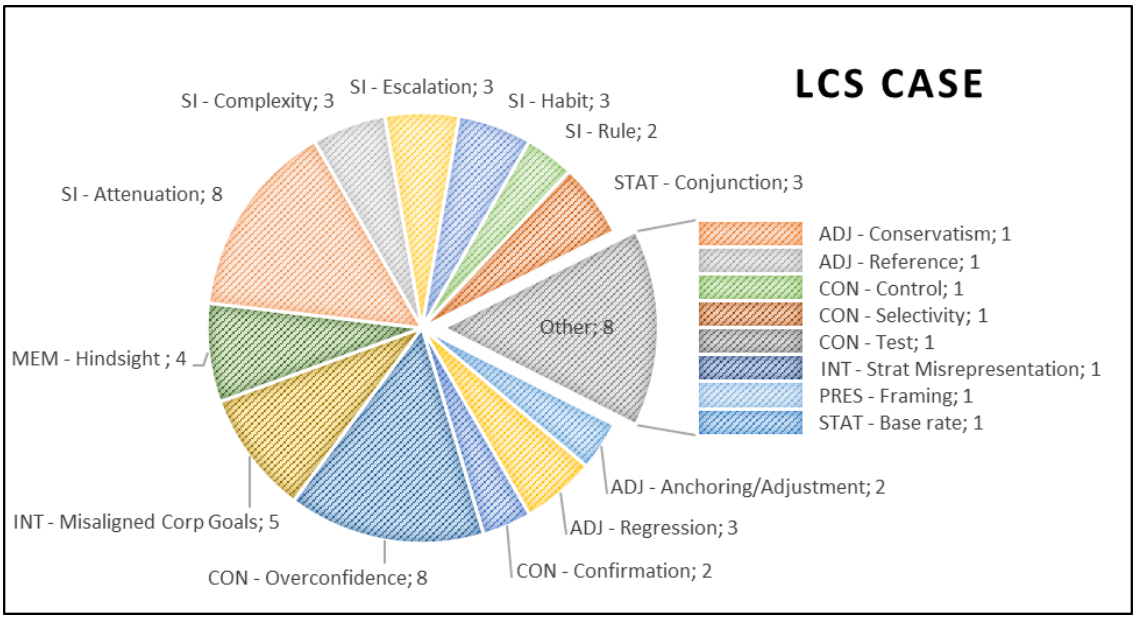

Figure 8. Assessed Decision Biases—LCS Case

The following individual biases or groupings of biases are highlighted and discussed in greater detail because they appear prevalently in our analysis and/or provide a unique illustrative view from an HBP perspective:

(1) Overconfidence (Con-5) and Attenuation (Si-1)

The "Overconfidence" bias was assessed in 30% of the passages cited within the case study. The "Attenuation" bias was also assessed in 30% of the passages cited within the case study. The following is an example of a passage where we assessed these two biases:

> To execute the program, the Navy deviated from traditional shipbuilding acquisition in hopes of rapidly delivering ships to the fleet. The consequences of this approach are well known today—costs to construct the

> ships have more than doubled from initial expectations, with promised levels of capability unfulfilled and deliveries significantly delayed. (GAO, 2016b, p. 1)

We assessed the "Overconfidence" bias for this passage because it appears the Navy likely underestimated the difficulty of rapidly delivering ships while deviating from traditional shipbuilding methods. Additionally, by deviating from traditional acquisition methods, the Navy decision makers were likely at a disadvantage with regards to their level of experience (i.e., skill or knowledge) with estimating acquisition outcomes using this novel technique, which is a situational indicator for the overconfidence bias (i.e., the Dunning-Kruger effect). We assessed the "Attenuation" bias for this passage because the Navy's decision likely involved "ignoring or significantly discounting the level of uncertainty" (Arnott, 1998, p.5) associated with adapting commercial designs to military specifications.

Finally, there were numerous instances where the "Overconfidence" and "Attenuation" biases (along with other biases) were assessed in relation to concurrency issues. We go into greater depth regarding concurrency in our third case, but GAO (2016b) provides a good example of concurrency in the LCS case: "In an effort to achieve its goals, the Navy deviated from sound business practices by concurrently designing and constructing the two lead ship variants while still determining the ship's requirements" (p. 4). While a concurrency strategy may be appropriate under exceptional and/or very unique circumstances, GAO found this practice to be prevalent among large defense acquisition programs, usually resulting in poor acquisition outcomes (GAO, 1990; GAO, 2012b). The need to make up for lost ground (typically schedule) does not subsequently alter the business case/logic underlying the original decision.

(2) Misaligned Perception of Corporate Goals (Int-3)

The "Misaligned Perception of Corporate Goals" bias was assessed in 19% of the passages cited within the case study. The following are two examples of passages where we assessed this bias:

> Making these commitments now could make it more difficult to make decisions in the future to reduce or delay the program should that be warranted. (GAO, 2016b, Highlights Page)

> GAO has reported extensively about what we refer to as the defense acquisition culture, a prevailing set of incentives that encourages decisions to go forward with programs before they are ready and a willingness to accept cost growth and schedule delays as the likely byproduct of such decisions. (GAO, 2016b, p. 16)

We assessed the "Misaligned Perception of Corporate Goals" bias for these passages because GAO implies and explicitly states that program participants were incentivized to view poor acquisition outcomes as a necessary tradeoff in pursuit of their own conflicting objectives (i.e., the program's continued existence). In the first passage, GAO highlights how the decision advocated by the program (i.e., committing to a block buy) conflicted with the Government's ability to make future decisions that would negatively impact the program. While Lovallo and Sibony's (2010) description of this bias speaks in terms of a company, this bias description can be adapted to hexarchies within defense acquisition. For instance, what is good for the Government as a whole, may not be perceived as in the best interest of an agency or program. This bias is closely aligned with GAO's incentives narrative. Lastly, we also assessed the "Overconfidence" bias for the first cited passage. This illustrates, from an HBP perspective, the ambiguity regarding the mix of cognitive and motivational factors that could have influenced the decision. We consider the existence/influence of these biases to both be plausible.

(3) Escalation (Si-3)

The "Escalation" bias was assessed in 11% of the passages cited within the case study. The following are example passages where we assessed this bias:

> A more basic oversight question today is whether a ship that costs twice as much yet delivers less capability than planned warrants an additional investment of nearly $14 billion. (GAO, 2016b, Highlights Page)

> Business case aside, the LCS program deviated from initial expectations, while continuing to commit to ship and mission package purchases. (GAO, 2016b, p. 4)

We assessed the “Escalation” bias for these passages since they either demonstrate a past propensity for programmatic escalation in terms of cost, schedule, or reduced capabilities; and/or a risk of further escalation (i.e., investing an additional $14B). In the cited passages and throughout the case study, GAO indicates that the current program has strayed far from the merits of its original business case. This indicates an escalation of commitment by attempting to salvage sunk costs. We suspect the escalation bias likely has an influence on decision makers within a program and those tasked with approving additional funding, schedule delays, reduced capabilities, etc., in the face of poor acquisition outcomes (i.e., the Milestone Decision Authority and Congress). While conducting our literature review, we noted numerous other GAO and acquisition reform studies/reports that indicate a widespread tendency for MDAPs to be susceptible to the influence of this bias. Therefore, we speculate that further study and interventions to mitigate this bias across defense acquisition programs are likely to yield significant positive results. Finally, our literature review and findings indicate the “Escalation” bias is likely to be present in situations where there are significant initial outlays and/or commitments (e.g., block buy strategy) where significant sunk costs are likely to encourage further escalation.

Figure 9 provides a word cloud illustration that graphically depicts the variety and frequency of the assessed decision biases within the case study. The size and color of the assessed biases are depicted relative to the frequency they were assessed, with bigger/ darker words indicating a higher frequency of assessment. However, the placement of the words within the word cloud are random.

Figure 9. Decision Bias Word Cloud Visualization— LCS Case

2. Primary Research Findings: Amphibious Combat Vehicle (GAO, 2018b)

a. *Case Overview*

The Amphibious Combat Vehicle (ACV) program's purpose is to "acquire an enhanced capability to transport Marines from ship-to-shore under hostile conditions … [and] "replace all or part of the current Assault Amphibious Vehicle (AAV) fleet" (GAO, 2018b, p. 1). At the time of the report's writing, the Marine Corps was nearing completion of system development and planned to initiate low-rate production for the ACV. Accordingly, GAO's stated objective was to inform this decision was to "assesses the extent to which the Marine Corps is making progress toward (1) meeting cost and schedule goals for the ACV program and (2) demonstrating manufacturing readiness" (GAO, 2018b, Highlights Page). The ACV program was initiated in 2011 and served as a direct replacement for the Expeditionary Fighting Vehicle (EFV) program. The EFV program was cancelled that same year due to affordability issues, costing approximately $3.7 billion over more than a decade in development (GAO, 2018b, p. 1). Summarizing the findings from their previous reports GAO found that the ACV program "made efforts to adopt best

practices and minimize acquisition risk, including: adopting an incremental approach to update capabilities, using proven technologies, increasing competition, and awarding fixed-price incentive contracts for much of the development work … [and] developed a high-quality reliable [life cycle] cost estimate" (GAO, 2018b, p. 7). The Marine Corps chose to develop the ACV incrementally, with each step (increment) upgrading the ACV's capabilities. Overall, the program was in good shape and had already been commended by GAO for implementing several sound acquisition practices. GAO described the first ACV increment (ACV 1.1) as "on track to meet development cost goals with no additional anticipated delays for major acquisition milestones" (GAO, 2018b, Highlights Page). The ACV Increment 1.1 two-phased strategy began in 2014 and resulted in five contractors submitting proposals with two successful resultant contractors competing for the down-select process in the second phase. GAO annually reviewed and reported to congressional defense committees the progress of the ACV 1.1 increment toward meeting cost and schedule goals and the program demonstrating manufacturing readiness. Specifically, GAO stated:

> [DOD] guidance for weapons acquisition production recommends that programs achieve [a manufacturing readiness level (MRL)] of 8 across all risk areas before entering low-rate production and that a program achieve an MRL of 9 at the start of full-rate production. GAO's previous reviews about manufacturing best practices found that achieving manufacturing maturity and identifying production risks early in the acquisition cycle and assessing those risks prior to key decision points, such as the decision to enter production, reduces the likelihood of quality issues, cost growth and delays. (GAO, 2018b, Highlights Page)

Accordingly, GAO recommended the Marine Corps "not enter the second year of low-rate production for ACV 1.1 until after the contractor has achieved an overall MRL of 8 and (2) not enter full-rate production until achieving an overall MRL of 9" (GAO, 2018b, Highlights Page). DOD partially concurred with GAO's recommendations, but contended that proceeding at a lower than recommended MRL could be achieved by taking steps to mitigate risk (GAO, 2018, pp. 19–20).

b. Findings

Our analysis of the ACV case identified 28 discrete instances where a decision bias was evident. Table 5 includes a summary of the coded decision biases, which are ranked based on number of occurrences. Figure 10 depicts the percentage that each bias category was represented for all of the assessed decision biases. Each bias category within the pie chart is the same color as the corresponding category within our DBD, detailed in Chapter III.

Table 5. ACV Case—Identified Decision Biases

Bias	**Assigned Bias Code**	**Number of Occurrences**
Control	Con-3	4
Overconfidence	Con-5	4
Success	Con-8	4
Attenuation	Si-1	4
Confirmation	Con-2	2
Desire	Con-4	2
Anchoring/Adjustment	Adj-1	1
Conservatism	Adj-2	1
Reference	Adj-3	1
Completeness	Con-1	1
Selectivity	Con-7	1
Misaligned Corp Goals	Int-3	1
Similarity	Mem-5	1
Framing	Pres-1	1

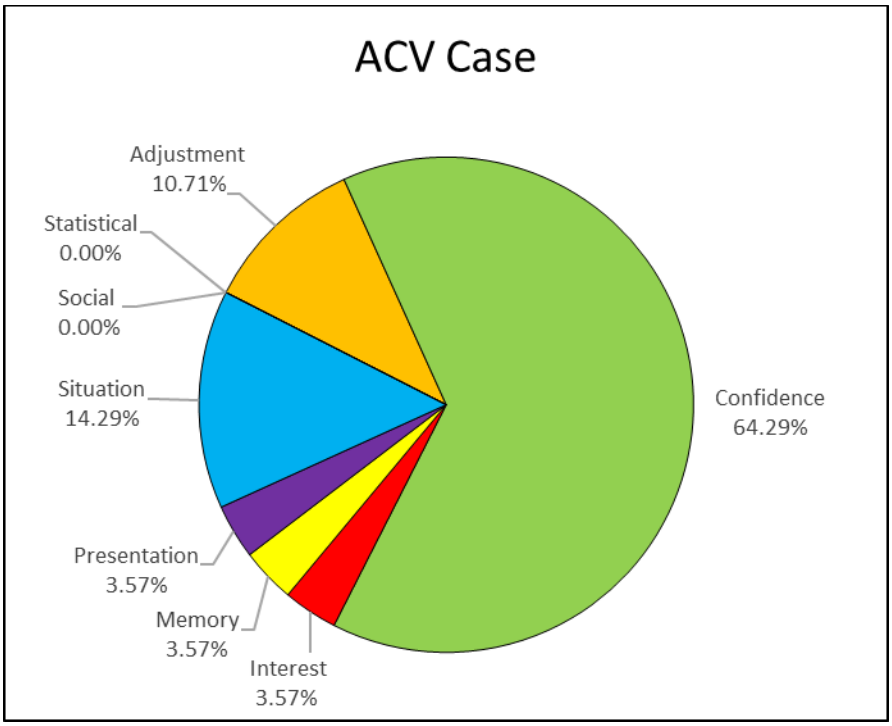

Figure 10. Categories of Identified Decision Biases—ACV Case

Figure 11 depicts the percentage that each individual bias was assessed within the case study. The pie chart graphically represents the incidence of every decision bias assessed for the case study; and is labeled with the bias category abbreviation, bias name, and number of times assessed.

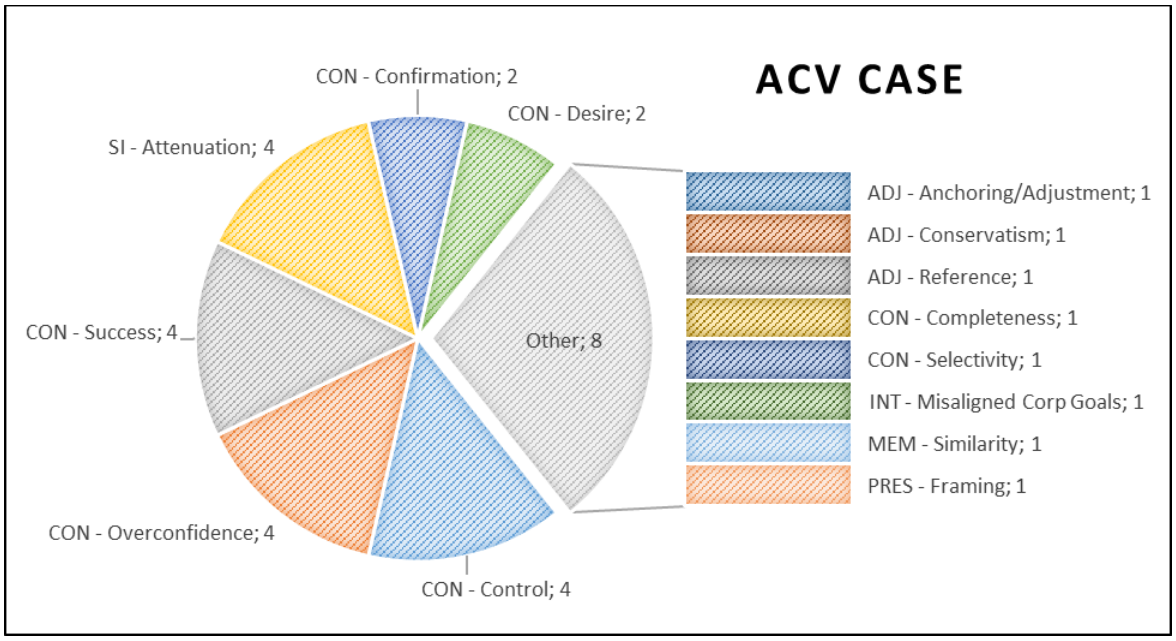

Figure 11. Assessed Decision Biases—ACV Case

The following individual biases or groupings of biases are highlighted and discussed in greater detail because they appear prevalently in our analysis and/or provide a unique illustrative view from an HBP perspective:

(1) Overconfidence (Con-5)

The "Overconfidence" bias was assessed in 36% of the passages cited within the case study. The following is an example passage where we assessed this bias:

> The ACV program office and DOD also indicated that they anticipate production costs will be within goals established at the start of development, though key production costs have not yet been determined. (GAO, 2018b, p. 9)

We assessed the "Overconfidence" bias for this passage because the DOD had confidence in achieving the ACV program's production cost goals exists even though key production costs had not been established. This passage also indicates the DOD's estimate was "unrealistically close to [the] best-case scenario" (Kahneman, 2011, p. 250), which is a situational indicator for the overconfidence bias.

(2) Success (CON-8)

The "Success" bias was assessed in 36% of the passages cited within the case study. The following is an example passage where we assessed this bias:

> The ACV program office is in the process of conducting tests and assessments to determine if the program is on track to meet the criteria to enter production, but program officials told us the Navy … may choose to start low-rate production without meeting established best practices for manufacturing maturity. (GAO, 2018b, p. 10)

We assessed the "Success" bias for this passage because this decision could have been based on confidence derived from the program's generally positive acquisition outcomes to date. According to GAO, these positive outcomes were correlated with following established sound acquisition practices, but this decision would deviate from these norms. Decision-makers within the program may take these positive outcomes as a validation of their decision making skill rather than the result of following sound acquisition practices.

(3) Control (Con-3)

The "Control" bias was assessed in 36% of the passages cited within the case study. The following is an example passage where we assessed this bias:

> As we also previously reported, however, the Marine Corps received a waiver to forgo the establishment of a certified Earned Value Management System [EVMS] for the ACV program, which reduces the regularly-available cost, schedule, and performance data available for the program to review. (GAO, 2018b, p. 9)

Whether or not the waiver of the EVMS requirement was merited or not, reducing the Government's visibility of cost, schedule, and performance metrics could induce the "Control" bias. Specifically, we assessed the "Control" bias because the reduced availability/visibility of key metrics may induce a false sense of control over these variables for program participants.

(4) Framing (Pres-1)

The “Framing” bias was only assessed in the following passage, but is included here to highlight a unique decision bias:

> Previously, the Marine Corps sought to achieve enhanced capabilities in these areas through the [EFV] program, but due to concerns about the program’s affordability, after more than a decade in development and the expenditure of $3.7 billion, the program was cancelled in 2011. Following the cancellation of the EFV program, [DOD] authorized the Marine Corps to seek a new replacement for the AAVs, emphasizing the need for cost-effectiveness, resulting in the start of the ACV acquisition in 2011. (GAO, 2018b, p. 1)

One can argue why the ACV program is distinct from the EFV program, but the fundamental intent for both programs was to replace all or part of the AAV fleet. By canceling the EFV program and starting the “new” ACV program, the DOD essentially wiped the slate clean of the “losses” associated with the EFV program. This is why we assessed the “Framing” bias for this passage. Changing the frame changed the perceived losses associated with acquiring the capability to replace the AAV fleet. This change in frame could have increased the influence of the “Overconfidence” and “Success” biases going forward.

(5) Similarity (Mem-5)

The “‘Similarity” bias was only assessed in the following passage, but is included here to highlight a unique decision bias:

> The Marine Corps considered the ACV to be a substantially non-developmental item [NDI] because both contractors’ designs were based on vehicles that were already in production and deployed by other militaries. (GAO, 2018b, p. 4)

We assessed the “‘Similarity” bias for this passage because, regardless of accuracy, the NDI classification could introduce the similarity bias by reducing the perceived likelihood of technical complications occurring based on the “degree of similarity with the class it is perceived to belong to” (Arnott, 2006, pp. 60–61) (i.e., vehicles which have already completed full-rate production). This can create overconfidence as seen further with production decisions. Carter et al. (2007) also defines the similarity bias as “The

likelihood of an event occurring may erroneously be judged by the probabilities of similar events" (p. 634). There are indications of this occurring in the case since the program justified eliminating the ACV's second most important source selection criterion, manufacturing capability, citing the ACV's NDI classification (GAO, 2018b, p. 12).

Figure 12 provides a word cloud illustration that graphically depicts the variety and frequency of the assessed decision biases within the case study. The size and color of the assessed biases are depicted relative to the frequency they were assessed, with bigger/ darker words indicating a higher frequency of assessment. However, the placement of the words within the word cloud are random.

Figure 12. Decision Bias Word Cloud Visualization—ACV Case

3. Primary Research Findings: Ford-Class Aircraft Carrier, CVN 78 (GAO, 2017b)

a. Case Background

GAO's report on the Navy's Ford-Class Aircraft Carrier Program (herein referred to as the "program") focused on the program as a whole, including the lead ship (CVN 78), the second ship (CVN 79), and two additional planned ships (CVN 80 & CVN 81). Considering the broad spectrum of issues addressed by GAO across the entire program within the report, we chose to focus our analysis exclusively on the GAO's discussions relating to CVN 78. However, we did consider passages that drew direct correlations between the CVN 78 acquisition and the remaining ships. According to GAO, while the Navy's intent for the program was to "improve combat capability while reducing acquisition and life-cycle costs … the lead ship [CVN 78] has experienced cost growth of nearly 23 percent, with a reduced capability expected at delivery" (2017b, Highlights Page). GAO pointed to "challenges with technology development, design, and construction, compounded by an optimistic budget estimate" (2017b, Highlights Page), as the primary factors leading to CVN 78's cost growth. In the report, GAO describes these shortfalls in detail, and highlights the Navy's continuing failure to apply these lessons learned, specifically related to cost estimating practices, to the remaining ships. GAO describes the Navy's goals for the program as an ambitious undertaking due to the inclusion of several cutting-edge technologies and new design features that were intended to "improve combat capability, while simultaneously reducing acquisition and life-cycle costs" (2017b, p. 3). GAO attributed 40% of CVN 78's cost growth and described numerous development challenges for the following critical technologies: Dual Band Radar (DBR), Advanced Arresting Gear (AAG), and Electromagnetic Aircraft Launch System (EMALS).

GAO compares the Navy's cost estimating practices with GAO's normative model for high-quality, reliable cost estimates, as established within GAO's Cost Estimating and Assessment Guide. GAO's normative model for cost estimating includes 20 best practices, which GAO (2017b) collapsed into the following four primary characteristics: 1) comprehensive, 2) accurate, 3) credible, and 4) well-documented (GAO, 2017b, p.6, 43–

45). Organizations that contribute to shipbuilding program cost estimates include Naval Sea Systems Command (NAVSEA) Cost Engineering and Industrial Analysis Group (05C), Naval Center for Cost Analysis (NCAA), the Office of the Secretary of Defense's Office of Cost Assessment and Program Evaluation (CAPE), and program office cost analyst personnel. A series of checks and balances among these entities are intended to ensure valid and verifiable estimates are prepared and reviewed prior to milestone events. Program office personnel are further "responsible for developing and annually updating the Cost Analysis Requirements Description, which includes the program acquisition approach, system characteristics and preliminary schedules" (GAO, 2017b, pp. 6–7). However, GAO found program officials continued to recommend continued funding of additional ships (using unrealistic cost estimates), even though the DBR, AAG, and EMALS critical subsystems continued to experience development significant development challenges. The lack of adequate progress in the ship's design and construction as well as the lack of successes in developmental testing of the above critical systems (and others) have significantly and negatively impacted the overall program cost, schedule, and proven capabilities of the weapon system.

b. Findings

Our analysis of the CVN 78 case identified 117 discrete instances where a decision bias was evident. Table 6 includes a summary of the coded decision biases, which are ranked based on number of occurrences. Figure 13 depicts the percentage that each bias category was represented for all of the assessed decision biases. Each bias category within the pie chart is the same color as the corresponding category within our DBD, detailed in Chapter III.

Table 6. CVN 78 Case—Identified Decision Biases

Bias	Assigned Bias Code	Number of Occurrences
Attenuation*	Si-1	15
Overconfidence*	Con-5	14
Anchoring/Adjustment*	Adj-1	12
Hindsight*	Mem-1	12

Bias	Assigned Bias Code	Number of Occurrences
Conjunction*	Stat-3	12
Control*	Con-3	10
Escalation*	Si-3	10
Misaligned Corp Goals	Int-3	5
Strat Misrepresentation	Int-4	5
Complexity	Si-2	4
Conservatism	Adj-2	3
Desire	Con-4	2
Success	Con-8	2
Test	Con-9	2
Framing	Pres-1	2
Reference	Adj-3	1
Confirmation	Con-2	1
Selectivity	Con-7	1
Linear	Pres-2	1
Scale	Pres-5	1
Chance	Stat-2	1
Disjunction	Stat-5	1

*Bias included in list of concurrency related biases.

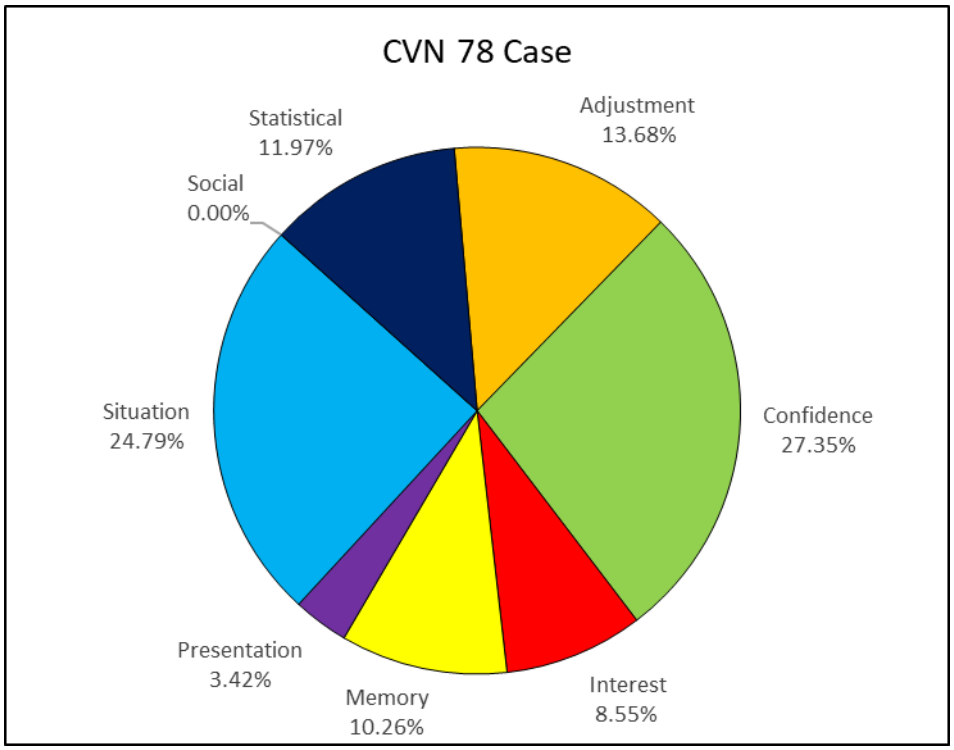

Figure 13. Categories of Identified Decision Biases—CVN 78 Case

Figure 14 depicts the percentage that each individual bias was assessed within the case study. The pie chart graphically represents the incidence of every decision bias assessed for the case study; and is labeled with the bias category abbreviation, bias name, and number of times assessed.

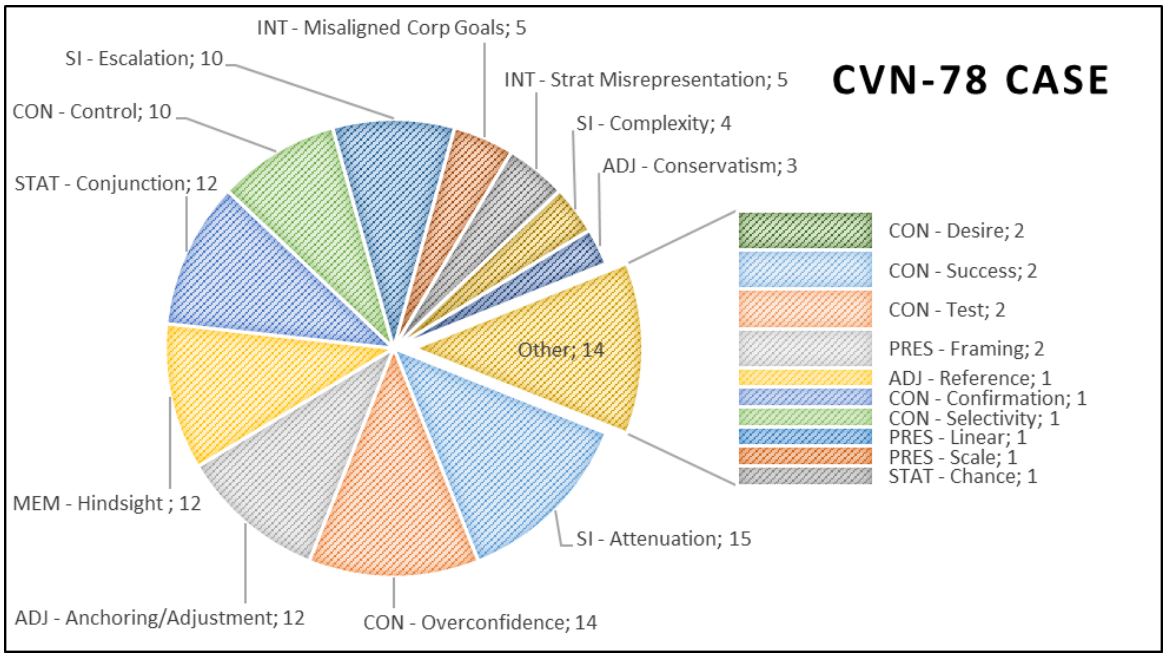

Figure 14. Assessed Decision Biases—CVN 78 Case

The following individual biases or groupings of biases are highlighted and discussed in greater detail because they appear prevalently in our analysis and/or provide a unique illustrative view from an HBP perspective:

(1) Concurrency Related Biases

There were several instances within this case study where GAO identified the Navy's implementation of concurrency strategies as deviations from sound acquisition practices. GAO has long highlighted concurrency in acquisition programs as a concern. GAO (2012b) defines and discusses GAO's position on concurrency as follows:

> Concurrency is broadly defined as overlap between technology development and product development or between product development

> and production of a system. This overlap is intended to introduce systems rapidly, to fulfill an urgent need, to avoid technology obsolescence, and to maintain an efficient industrial development and production workforce. However, while some concurrency is understandable, committing to product development before requirements are understood and technologies mature as well as committing to production and fielding before development is complete is a high-risk strategy that often results in performance shortfalls, unexpected cost increases, schedule delays, and test problems. At the very least, a highly concurrent strategy forces decision makers to make key decisions without adequate information about the weapon's demonstrated operational effectiveness, reliability, logistic supportability, and readiness for production. … In contrast, our work has found that successful programs that deliver promised capabilities for the estimated cost and schedule follow a systematic and disciplined knowledge-based approach, in which high levels of product knowledge are demonstrated at critical points in development. (p. 7; see also GAO, 1990, p. 1–2)

To increase the consistency and inter-rater reliability within our analysis, we took the additional step to predetermine a selection of assessed decision biases when assessing biases related to concurrency strategies. After screening the cited passages to ensure the same decisions/situations were not counted twice, we still found that 28% of the passages cited within the case were specifically related to concurrency strategies. Therefore, the inclusion or exclusion of biases from our predetermined list of concurrency biases had a significant impact on how prevalent these bias ultimately appeared in our analysis. In addition to thoroughly vetting our list of predetermined biases; we chose between biases with overlapping definitions, and identified additional biases as applicable, if certain criteria were met for a particular passage. Finally, our list of concurrency biases is applicable specifically to concurrency strategies that were implemented after-the-fact (i.e., not planned concurrency strategies). The following list of concurrency related biases also includes the percentage the bias was assessed within the entire case study, not just for the concurrency related passages:

Anchoring and Adjustment (Adj-1): 41%

Control (Con-3): 34%

Overconfidence (Con-5): 48%

Attenuation (Si-3): 52%

Escalation (Si-3): 34%

Hindsight (Mem-1): 41%

Conjunction (Stat-3): 41%

The following is an example passage where we assessed these biases.

> Navy elected to proceed with production of some critical technologies prior to fully demonstrating their capability, in an effort to maintain the construction schedule. A strategy of concurrent test and production ensued, often leading to changes in components that had already been produced. (GAO, 2017b, p. 11)

Instead of explaining why these biases were assessed for this particular passage, the following is a summary of our rationale for assessing these biases for concurrency passages in general. We included the "Anchoring and Adjustment" bias for concurrency since cost, performance, or schedule changes are situational indicators for this bias. Especially in situations where a program is seeking to catch up schedule delays, the "Anchoring and Adjustment" bias is likely to result in insufficient adjustments from an initial anchor (original schedule) when determining a realistic revised schedule. We included the "Control" bias since concurrency triggers several situational indicators for this bias. According to Arnott (1998), the "Control" bias can occur when "subjective probabilities of an event are systematically assessed to be higher than the relevant objective probabilities" (p. 9), and can be triggered by rigorous planning or even thinking about an event. We believe concurrency fits this description. Additionally, Langer (1975) found this bias was most prevalent in conditions where a chance task/environment is similar to a skill task/environment, and Koehler, Gibbs, and Hogarth (1994) found that decision makers are more susceptible to the control bias when they are faced with unique, low-frequency decision events. These situational indicators coincide with concurrency. We included the "Overconfidence" bias because concurrency strategies usually rely upon schedule plans/ estimates that "are unrealistically close to best-case scenarios … [and] could be improved by consulting the statistics of similar cases" (Kahneman, 2011, p. 250). Finally,

concurrency within a highly complex defense weapons program definitely fits the bias' situational indicator of seeking "to solve difficult or novel problems" (Arnott, 2006, pp. 60–61). We included the "Attenuation" bias because concurrency strategies often require "ignoring or significantly discounting the level of uncertainty" (Arnott, 2006, pp. 60–61). We included the "Escalation" bias because concurrency strategies almost always are a result of an escalation of commitment (i.e., catching up schedule). Two additional situational indicators of this bias are the existence of sunk costs (i.e., schedule delays) (Northcraft & Wolf, 1984), and when the original decision is announced publicly (Beeler & Hunton, 1997). We included the "Hindsight" bias because concurrency strategies are still implemented, even though there numerous examples of poor acquisition outcomes going back decades. Implementing a concurrency strategy may indicate a susceptibility to this bias by failing to learn from past events, thinking "This time, it's different." or "They didn't have as good a plan as I have in place." Finally, we included the "Conjunction" bias because concurrency is a compound event "where each element of the compound event contributes to the final outcome" (Arnott, 1998, p 8). According to Arnott, the "Conjunction" bias commonly occurs "when all elements must be completed on schedule for the final outcome to be on time [and] … excessive optimism … in estimating the total time required to complete a complex project" (1998, pp. 8–9).

Concurrency strategies are not always bad decisions. For instance, if a required capability is desperately needed for the Nation's defense, the DOD might pursue a concurrency strategy where significant cost overruns and/or duplicative capabilities are acceptable. However, GAO's position is that concurrency strategies usually results in poor acquisition outcomes. If a concurrency strategy was not determined to be a good decision to begin with, then it is unlikely the existence of schedule delays would alter the original business case. Often, concurrency strategies end up compounding the schedule delays they were meant to mitigate. Fundamentally, concurrency often results in the program chasing after "sunk costs" (usually schedule delays) by taking additional schedule and/or cost risks. Concurrency was a common theme we encountered in our analysis, and many of the sources reviewed during our literature review indicated concurrency is a widespread practice among acquisition programs. Therefore, we speculate that further study and

interventions to mitigate the decision biases likely to encourage concurrency strategies are likely to yield significant positive results.

(2) Strategic Misrepresentation (Int-4)

The behavior we defined as "Strategic Misrepresentation" was assessed in 17% of the passages cited within the case study. The following is an example passage where we assessed this behavior:

> In 2014, we reported that the extent to which CVN 78 would be delivered on time and within the Navy's $12.9 billion estimate was dependent on the Navy's plan to defer work and costs to the postdelivery period. We found that CVN 78 would deploy without demonstrating full operational capabilities because it could not achieve certain key requirements—such as increasing launch and recovery rates—according to its test schedule. We also found that the Navy was implementing steps to achieve the congressional cost cap for CVN 79, but that they were largely based on ambitious efficiency gains and reducing a significant amount of construction, installation, and testing—work traditionally completed prior to ship delivery. … However, we suggested that Congress consider revising the cost cap legislation to ensure that all work included in the initial ship cost estimate that is deferred to postdelivery is counted against the cost cap; if warranted, we noted, the Navy could seek statutory authority to increase the cap. (GAO, 2017b, p. 5)

We assessed the "Strategic Misrepresentation" for this passage because we interpreted the Navy's decision to "defer work and costs to the postdelivery period" (p. 5) as a "planned, systematic distortion or misstatement of fact" (Jones & Euske, 1991, p. 437) in order to stay below the cost cap and reduce the perception of further cost growth for the program. According to GAO, Congress created procurement cost caps for the program to "help ensure that the Navy adhered to its cost estimates" (p. 1). Even after considering the Navy's comments regarding GAO's conclusions, we interpreted these decisions to be at least partly incentive-driven and supportive of GAO's incentives narrative. While we were able to assess other decision biases for this passage, including "Misaligned Perception of Corporate Goals," we determined that our Decision Bias Dictionary (DBD) did not have a decision bias that fully captured these incentive-driven behaviors. Accordingly, we added "Strategic Misrepresentation" to our DBD even though it technically is a conscious decision rather than a cognitive or motivational bias. However, as detailed in Chapter II,

for simplicity, we chose to classify “Strategic Misrepresentation” as a motivational bias since it is still relevant to our research and these behaviors coincide with GAO’s incentives narrative. Ignoring these behaviors just because they are not technically considered decision biases would not give GAO’s incentives narrative proper consideration in our analysis.

Figure 15 provides a word cloud illustration that graphically depicts the variety and frequency of the assessed decision biases within the case study. The size and color of the assessed biases are depicted relative to the frequency they were assessed, with bigger/ darker words indicating a higher frequency of assessment. However, the placement of the words within the word cloud are random.

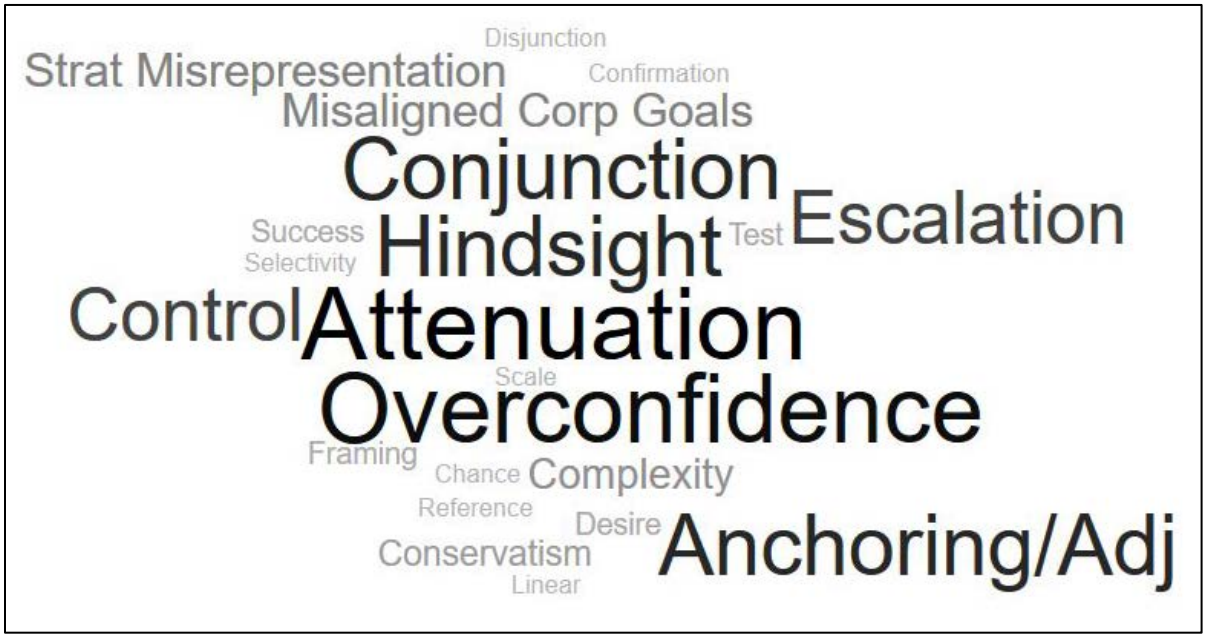

Figure 15. Decision Bias Word Cloud Visualization—CVN 78 Case

4. Primary Research Findings: Tactical Aircraft, F-22A Modernization Program (GAO, 2012a)

a. Case Background

The Air Force's modernization program for the F-22A program is continually expanding. As threats change, requirements and missions change, so too must this program adapt to a robust set of ever-changing threats through the addition of new capabilities. Spiral developments were replaced with increments in the early phases of the program. Modernization efforts associated with increments 2, 3.1 and 3.2A were developed and tested in concert with the production phase of this program and costs associated with those increments were included in the programs baseline. These events happened long before the recognition of increment 3.2B as a separate MDAP. Those increments were included as delivery orders under the umbrella of a 10-year, $6 billion IDIQ contract that was awarded in 2003. The ceiling on that contract was later increased as mission changes and further capabilities were added and developed. After expiration of the current IDIQ ordering period, a subsequent IDIQ contract was awarded for the programs continued modernization efforts. "Rather than making the new business case to justify and manage the modernization program as a separate major defense acquisition, Air Force officials incorporated it within the existing F-22A acquisition program and comingled funds" (GAO, 2012a, p. 11). Some of the earlier projects and increments were not recognized as separate MDAPS, even though the costs associated with these efforts were significant.

b. Findings

Our analysis of the F22A case identified 28 discrete instances where a decision bias was evident. Table 7 includes a summary of the coded decision biases, which are ranked based on number of occurrences. Figure 16 depicts the percentage that each bias category was represented for all of the assessed decision biases. Each bias category within the pie chart is the same color as the corresponding category within our DBD, detailed in Chapter III.

Table 7. F22A Case—Identified Decision Biases

Bias	Assigned Bias Code	Number of Occurrences
Attenuation	Si-1	5
Complexity	Si-2	3
Conjunction	Stat-3	3
Anchoring/Adjustment	Adj-1	2
Overconfidence	Con-5	2
Selectivity	Con-7	2
Correlation	Stat-4	2
Conservatism	Adj-2	1
Control	Con-3	1
Desire	Con-4	1
Test	Con-9	1
Misaligned Corp Goals	Int-3	1
Hindsight	Mem-1	1
Scale	Pres-5	1
Habit	Si-4	1
Disjunction	Stat-5	1

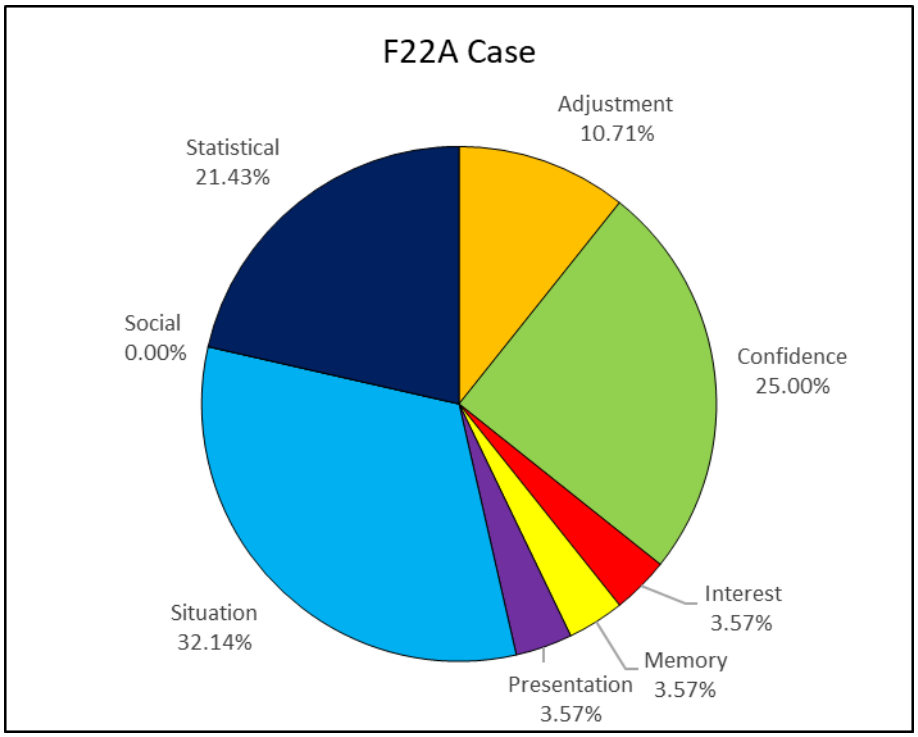

Figure 16. Categories of Identified Decision Biases—F22A Case

Figure 17 depicts the percentage that each individual bias was assessed within the case study. The pie chart graphically represents the incidence of every decision bias assessed for the case study; and is labeled with the bias category abbreviation, bias name, and number of times assessed.

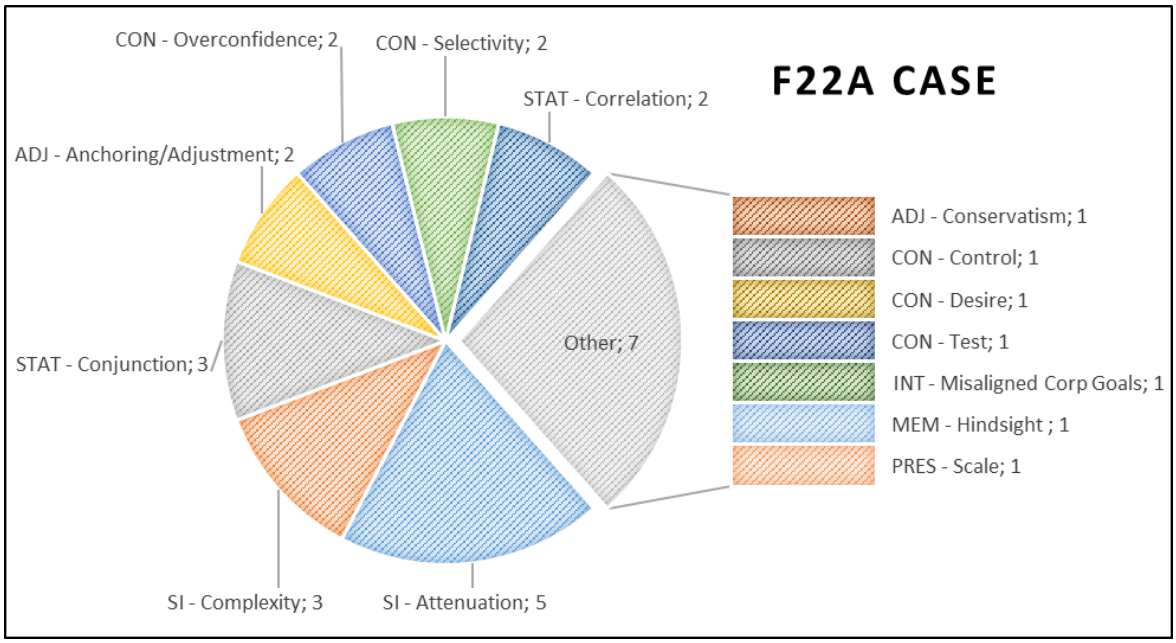

Figure 17. Assessed Decision Biases—F22A Case

The following individual biases are highlighted and discussed in greater detail because they provide a unique illustrative view from an HBP perspective:

(1) Scale (Pres-5)

The "Scale" bias was only assessed in the following passages, but is included here to highlight a unique decision bias:

> Visibility and oversight of the program's cost and schedule is hampered by a management structure that does not track and account for the full cost of specific capability increments. Substantial infrastructure costs for labs, testing, management, and other activities directly support modernization but are not charged to its projects. …

> GAO recommends that DOD evaluate capabilities to determine if future F-22A modernization efforts meeting DOD policy and statutory requirements should be established as separate major acquisition programs. (GAO, 2012a, Highlights Page)

According to Arnott (2006), "The perceived variability of data can be affected by the scale of the data" (pp. 60–61). For instance, a $100,000 cost overrun on a $1M acquisition can be perceived as significantly more of a concern than a $100,000 cost overrun on a $100M acquisition. In fact, we speculate that the "Scale" bias is likely to have a significant level of influence across all DOD MDAPs do to the inherently massive scale of these programs. However, in this particular case, increasing the scale of the acquisition was unnecessary, and according to GAO, was a poor decision. Accordingly, we assessed the "Scale" bias for this passage because the failure to track each increment as a separate MDAP unnecessarily increased the scale with which cost data was perceived by the program as a whole. This bias was assessed for the CVN 78 case for a similar reason.

(2) Test (Con-9)

The "Test" bias was only assessed in the following passage, but is included here to highlight a unique decision bias:

> Air Force officials stated that potential new capabilities are analyzed and vetted by evaluating technical maturity and applying cost as independent variable principles to determine which to include in the F-22A modernization program. … Tracking and accounting for the full and accurate cost of each modernization increment, and individual projects within each increment, are limited by the way the modernization program is structured, funded, and executed. (GAO, 2012a, p. 9)

We assessed the "Test" bias for this passage because the modernization program's tracking and accounting structure negates the ability to test/validate the cost information used to partly justify the inclusion of a potential new capability. GAO defines the "cost as an independent variable" principle as the "establishment of cost goals for operations, sustainment, and procurement, and for acquisition programs to make trade-offs in terms of cost, schedule, and performance" (2012a, p. 9). However, due to the program's funding structure, the Air Force is unlikely to be able to test whether the capability's cost goals, which were derived from their "cost as an independent variable" calculations, were

accurate. According to Arnott (2006), unrealistic confidence often arises in decisions where the "outcomes of choice cannot be tested" (pp. 60–61).

Figure 18 provides a word cloud illustration that graphically depicts the variety and frequency of the assessed decision biases within the case study. The size and color of the assessed biases are depicted relative to the frequency they were assessed, with bigger/ darker words indicating a higher frequency of assessment. However, the placement of the words within the word cloud are random.

Figure 18. Decision Bias Word Cloud Visualization—F22A Case

5. Primary Research Findings: Joint Strike Fighter (JSF) (GAO, 2009)

a. Case Background

The next-generation Joint Strike Fighter (JSF) (a.k.a. F-35) Program was described by GAO (2009) as the DOD's "most complex and ambitious aircraft acquisition, seeking to simultaneously produce and field three different versions of the aircraft for the Air Force, Navy, Marine Corps, and eight international partners" (Highlights Page). Our analysis reviewed GAO's findings using the HBP perspective, but we did not attempt to incorporate later developments for the program in our analysis. Rather, our analysis is a snapshot of the JSF program at the time the report was written. The JSF's planned capabilities included being able to transition between engaging targets in the air and/or on the ground while still airborne, stealth technologies, "defensive avionics, advanced onboard and offboard sensor fusion, internal and external weapons, and advanced prognostic maintenance capability" (p. 4). In addition, the JSF design consisted of three major variants, each customized for the needs of the Air Force, Marine Corps, and Navy. At the time of the report's writing, the JSF program planned to acquire 2,456 aircraft at an estimated cost of over $1T ($300B for initial acquisition, and $760B in life cycle costs), spanning almost four decades. Needless to say, the JSF program is incredibly complex, and is critical to ongoing and future U.S. air superiority. GAO's purpose was to (1) [determine] the program's progress in meeting cost, schedule, and performance goals; (2) [assess] manufacturing results and schedule risks; and (3) [evaluate] development test plans, progress, and risks" (2009, Highlights Page). GAO found the program will "cost more and take longer than reported to the Congress [in the previous year]" (Highlights Page) In spite of this, DOD wanted to accelerate 169 planned JSF procurements, and intended to procure hundreds of aircraft using cost-reimbursement versus fixed price contracts. GAO also expressed concern with DOD's plan to reduce planned test aircraft and real world flight tests by relying on "state-of-the-art simulation labs, a flying test bed, and desk studies to verify nearly 83% of JSF capabilities" (Highlights Page) GAO cautioned against "significant overlap [i.e., concurrency] of development, test, and procurement results" (Highlights Page), with 360 aircraft planned to be procured prior to completion of development flight testing.

b. Findings

Our analysis of the JSF case identified 120 discrete instances where a decision bias was evident. Table 8 includes a summary of the coded decision biases, which are ranked based on number of occurrences. Figure 19 depicts the percentage that each bias category was represented for all of the assessed decision biases. Each bias category within the pie chart is the same color as the corresponding category within our DBD, detailed in Chapter III.

Table 8. JSF Case—Identified Decision Biases

Bias	**Assigned Bias Code**	**Number of Occurrences**
Attenuation	Si-1	19
Overconfidence	Con-5	14
Hindsight	Mem-1	11
Control	Con-3	9
Anchoring/Adjustment	Adj-1	8
Conservatism	Adj-2	8
Conjunction	Stat-3	7
Reference	Adj-3	6
Misaligned Corp Goals	Int-3	6
Desire	Con-4	5
Selectivity	Con-7	5
Completeness	Con-1	4
Complexity	Si-2	4
Escalation	Si-3	3
Disjunction	Stat-5	3
Imaginability	Mem-2	2
Test	Con-9	1
Inappropriate Attachments	Int-2	1
Strat Misrepresentation	Int-4	1
Framing	Pres-1	1
Inconsistency	Si-5	1
Base rate	Stat-1	1

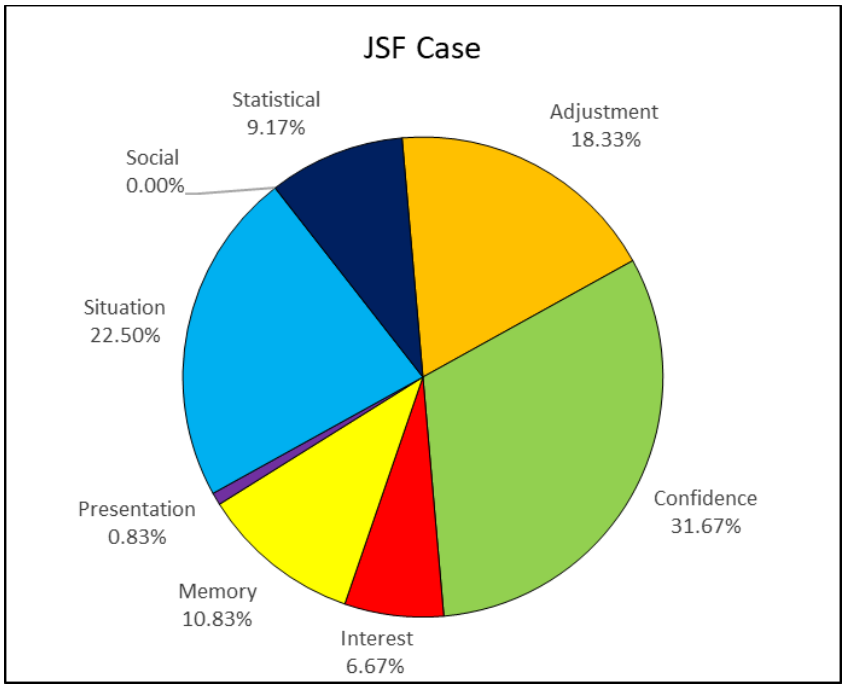

Figure 19. Categories of Identified Decision Biases—JSF Case

Figure 20 depicts the percentage that each individual bias was assessed within the case study. The pie chart graphically represents the incidence of every decision bias assessed for the case study; and is labeled with the bias category abbreviation, bias name, and number of times assessed.

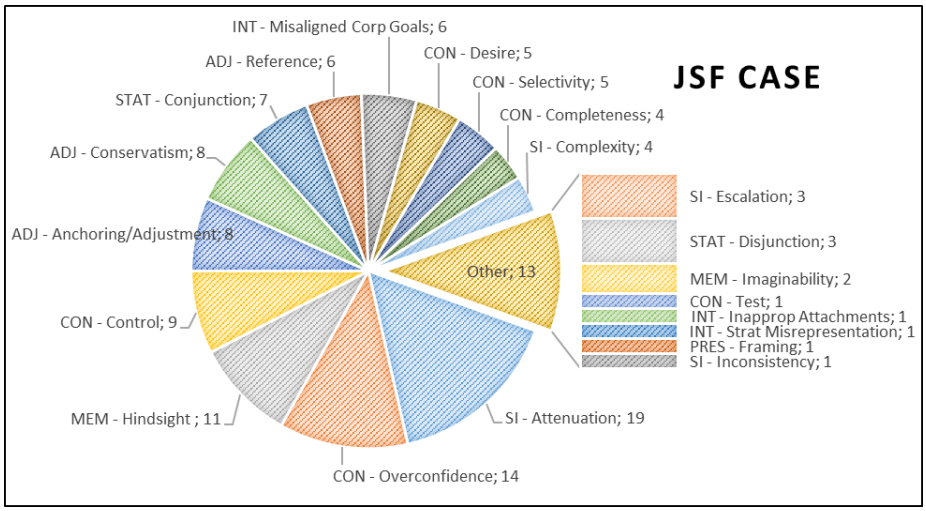

Figure 20. Assessed Decision Biases—JSF Case

The following individual biases are highlighted and discussed in greater detail because they appear prevalently in our analysis and/or provide a unique illustrative view from an HBP perspective:

(1) Conservatism (Adj-2) and Hindsight (Mem-1)

The "Conservatism" bias was assessed in 21% of the passages cited within the case study. The "Hindsight" bias was assessed in 28% of the passages cited within the case study. The following is an example of a passage where we assessed both of these biases:

> Development costs are projected to increase between $2.4 billion and $7.4 billion and the schedule for completing system development extended from 1 to 3 years, according to recent estimates—one by the JSF Program Office and one by a joint team of Office of the Secretary of Defense (OSD), Air Force, and Navy officials. Cost overruns on both the aircraft and engine contracts, delays in manufacturing test aircraft, and a need for a longer, more robust flight test program are the primary cost drivers. The joint team's estimate is higher than the program office's because it included costs for the alternate engine program directed by the Congress and used more conservative assumptions based on current and legacy aircraft experiences. Program officials contend that funding the program to the higher cost estimate is premature and believe processes are in place to substantially improve on the test experiences of past programs. (GAO, 2009, pp. 7–8)

We assessed the "Conservatism" bias for this passage because the program failed to revise their cost estimates appropriately to account for significant new data (i.e., alternate engine program costs). GAO noted the alternate engine program was directed by Congress in order to "induce competition and to ensure that one engine's failures would not ground all JSFs, thereby reducing operational risks in the future" (pp. 9–10). However, DOD chose to not include funding for the alternate engine program within their estimate (p. 10). The "Conservatism" bias is classified as an "Adjustment" bias, and is similar to the Anchoring and Adjustment' bias in that both arise from the cognitive difficulty humans experience when attempting to adjust from an initial position. Our tentative analysis findings and literature review leads us to conclude both of these biases are likely have a widespread and significant influence within defense acquisition programs.

We assessed the "Hindsight" bias for this passage because the program indicated an unwillingness to incorporate lessons learned from past events, ignoring the "more

conservative assumptions based on current and legacy aircraft experiences" (p. 8) used by the joint team. Regardless of the validity of the program's more optimistic reliance on improved testing processes, the context of the situation is a situational indicator for the "Hindsight" bias. Essentially the program is contending that 'This time, it's different', and discounting the applicability of lessons learned from past programs. In fact, it is likely these past programs also suffered from this same bias. Finally, while it is likely individual defense acquisition programs are influenced by the "Hindsight" bias, we also believe that GAO and defense acquisition reformers are just as susceptible to this bias when judging decisions made with the benefit of hindsight. As indicated in Chapter II, we believe this bias is an especially important cognitive bias for acquisition reformers to mitigate since acquisition reform efforts have failed to solve the same fundamental problems over the past 60 years (Fox, 2009, p. 35).

(2) Desire (Con-4)

The "Desire" bias was assessed in 13% of the passages cited within the case study. The following is an example passage where we assessed this bias:

> DOD will make significant investments—in both dollars and the number of aircraft procured—before completing JSF flight testing. DOD's proposal to accelerate procurement further increases financial risks in a very challenging test environment. … DOD decisions to reduce development test aircraft and flight tests add to the risks, while any additional delays in manufacturing test aircraft will further compress the schedule. … The department has stated that the contractor's state-of-the-art ground test labs and a flying test bed will mitigate risks in the flight regimen and their use will effectively substitute for flight testing. This approach is promising, but not yet proven. (GAO, 2009, p. 20)

GAO noted the program planned to verify an unprecedented 83% of the JSF's capabilities using "series of advanced and robust simulation labs … [a] flying test bed, and subject matter analysis" (p 24); and cautioned "the ability to substitute [these methods] for flight testing has not yet been demonstrated" (p.25). We assessed the "Desire" bias, among others, for this passage because the program's confidence in this "unprecedented" testing strategy was likely significantly influenced by their desired outcomes (i.e., schedule acceleration). Olsen (1997) found that even experts making decisions within their area of

expertise are susceptible to the "Desire" bias. Therefore, the possible influence of this bias among the ranks of highly intelligent experts within the program is not at all unlikely. As detailed in Chapter II, while the "Desire" bias is generally categorized as a cognitive bias, we found no clear consensus among decision bias researchers regarding the influence of motivational factors for this bias. Similar to the "Overconfidence" bias, a greater understanding of how cognitive and motivational factors interact to create the "Desire" bias is central to achieving a synthesis between the HBP and GAO's incentives narrative.

Figure 21 provides a word cloud illustration that graphically depicts the variety and frequency of the assessed decision biases within the case study. The size and color of the assessed biases are depicted relative to the frequency they were assessed, with bigger/ darker words indicating a higher frequency of assessment. However, the placement of the words within the word cloud are random.

Figure 21. Decision Bias Word Cloud Visualization—JSF Case

B. SECONDARY RESEARCH FINDINGS

Based upon our review of the fundamental assumptions, historical development, and empirical research/critical reviews supporting GAO's incentives narrative, we cannot reasonably determine GAO's incentives narrative to be well-founded or conclusive. It appears there has been little research into the true nature and impact of how incentive-driven decision biases shape acquisition decisions.

In our review of major acquisition reform and GAO studies' findings concerning defense acquisition culture and incentives spanning the past 60 years, we found no empirical research supporting the incentives narrative, no critical reviews of the assumptions underlying the incentives narrative, and no attention given to alternative theories developed within the decision science literature during the same time period. It appears that major acquisition reform/GAO studies over the past 60 years have developed largely independent of advancements in behavioral decision theory during the same time period. We also found that GAO's seminal 1992 study of 81 of their previous works on defense acquisition programs from 1976—1991 essentially established GAO's incentives narrative. The 1992 GAO report's conclusions were based on subjective judgement, "corporate knowledge" (p. 13), and unexamined assumptions. However, the 1992 report did not represent its narrative as the "singular correct view" (GAO, pp. 2–3). Despite the apparent lack of supporting evidence, the report's conclusions have largely persisted within GAO's successive reports' narratives. Many of GAO's subsequent reports that discuss defense acquisition culture and incentives paraphrased and/or borrowed verbatim large sections of the narratives of the 1992 report and/or from each other. Considering this, it appears that GAO's incentives narrative has largely been unquestioningly accepted by GAO, Congress, and the defense acquisition community. This reliance has possibly resulted in acquisition reform efforts that have not adequately examined the underlying causes of decision biases within defense acquisition programs.

In addition, many of GAO's recommendations for addressing poor acquisition outcomes have focused on the need to remove negative incentives which—according to the incentives narrative—drive incentive-driven decision biases. In addition to an absence of research relating to additional or alternative causal influences for decision biases, there

appears to be little to no research within the defense acquisition community examining the nature and impact of incentive-driven decision biases. GAO's recommendations regarding negative incentives have largely focused on eliminating negative incentives rather than mitigating the influence of incentive-driven decision biases on decision makers. Removing the negative incentives highlighted by GAO has proved an intractable problem since these incentives are often engrained into the structure and culture of the Defense Acquisition System (Fox, 2011). However, even if all of the negative incentives identified by GAO were somehow eliminated, this would not eliminate or mitigate the influence of cognitive biases that are at least partly responsible for deviations from sound acquisition practices. Therefore, acquisition reform efforts must address both categories of decision biases to improve acquisition outcomes.

C. SUMMARY

This chapter discussed our findings and the results of our analysis for our primary and secondary research objectives. Next, Chapter V details our conclusions, and provides recommendations for further research.

V. CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

This chapter details the conclusions and recommendations based upon our research findings, and provides several suggestions for further research.

A. CONCLUSIONS AND RECOMMENDATIONS

Our findings indicate that decisions within defense acquisition programs may be susceptible to a broad range of cognitive biases, which could influence deviations from sound acquisition practices. Our research did not seek to disprove the incentives narrative, nor did it seek to prove conclusively that cognitive biases significantly contribute to deviations from sound acquisition practices. We expected at the outset that the limited scope and focus of our research would raise more questions and lines of further inquiry than provide definitive recommendations or conclusions. However, our research findings did allow us to draw the following conclusions and/or recommendations.

Based on our review of the rationale, underlying assumptions, and supporting evidence, we found GAO's incentives narrative to be neither well-founded nor conclusive. We found no empirical research supporting the incentives narrative, no critical reviews of the assumptions underlying the incentives narrative, and no attention given to alternative theories developed within the decision science literature during the same time period. Also, we found the conclusions made within a 1992 GAO report, which essentially established GAO's incentives narrative, to have largely persisted within GAO's successive reports' narratives (GAO, 1992). This is despite the 1992 report stating that its conclusions were based on subjective judgement and "corporate knowledge" (p. 13), and stating the report's narrative was not presented as the "singular correct view" (GAO, 1992, pp. 2–3). Many of GAO's subsequent reports/published testimonies that discuss defense acquisition culture and incentives paraphrased and/or borrowed verbatim large sections of the narratives from the 1992 report and/or from each other. In spite of the narrative's intuitive appeal, failing to rigorously examine and validate an assumption so central to shaping GAO's recommendations for defense acquisition reform is a significant oversight. Accordingly,

we recommend GAO critically review the key assumptions underlying the incentives narrative and determine whether these assumptions are objectively supported by data or empirical evidence. Absent such a critical review, we recommend ongoing and future defense acquisition reform efforts not rely upon the incentives narrative as a well-established point of fact.

Our findings indicate that it is possible, or even likely, that cognitive biases contribute to deviations from sound acquisition practices. While our research is limited in its ability to draw broad conclusions due to the sample size and limited scope of our analysis, our findings provide an illustrative view of an alternative narrative (i.e., heuristics and biases paradigm [HBP]) to explain widespread deviations from sound acquisition practices. This illustrative view was achieved by examining the selected case study transcripts through the lens of the HBP perspective rather than the rational choice model (RCM) perspective. This alternative narrative is bolstered by a robust body of knowledge, which is vast and expanding, supported by scientifically robust and repeatable experimental evidence, and is widely considered to be generalizable to a broad range of fields of study (Heuer, 1999; see also Arnott, 1998, p. 3). This conclusion is also affirmed by widespread application of HBP within numerous fields of study such as economics, psychology, medicine, law, finance, etc.; and its' extensive application by the CIA for intelligence analysis (Heuer, 1999), and by the DOD for military strategy (Kahneman, 2011; Hillemann et al., 2015; and UFMCS, 2016). GAO's incentives narrative and the HBP alternative narrative are both plausible, and they both require further research and supporting evidence to be reconciled into a unified model of decision making. Instead of 'rounding up the usual suspects' (i.e., acquisition culture and incentives) to explain poor acquisition outcomes, we urge GAO and defense acquisition reformers to consider additional/alternative causal narratives. Accordingly, we recommend defense acquisition reform efforts consider the HBP perspective when seeking root causes for deviations from sound acquisition practices.

The following biases were most prevalent in our analysis and have situational indicators that are likely common across defense acquisition programs: 1) "Attenuation," 2) 'Overconfidence', and 3) "Hindsight." 1) There were 51 discrete instances where the

"Attenuation" bias code was assigned, accounting for 14.7% of all of the biases identified during our analysis. The "Attenuation" bias is likely to impact a defense acquisition program when decisions are simplified by "ignoring or significantly discounting the level of uncertainty" (Arnott, 1998, p.5), or when a decision maker eliminates what he/she believes to be unimportant or unlikely variables in a decision (Stoker, 1996). According to Arnott (1998) "Attenuation" "enables a person to cope with a complex, information rich environment [but often results in] arbitrary and inconsistent processes that act to exclude information" (p. 5). This bias can be mitigated by implementing general debiasing techniques, such as a pre-mortem analysis (UFMCS, 2014; Klein, 2004). 2) There were 42 discrete instances where the "Overconfidence" bias code was assigned, accounting for 12.1% of all of the biases identified during our analysis. The "Overconfidence" bias is likely to be present in defense acquisition programs that exhibit cost, schedule, and performance estimates that are "unrealistically close to [the] best-case scenario" (Kahneman, 2011, p. 250); or when a decision maker seeks "positive rather than negative evidence" (Koriat et al., 1980, p. 116), or is presented with an abundance of data (Sage, 1981). Additionally, decision makers that are at a disadvantage with regards to their knowledge, skill, or experience are likely to exhibit the "Overconfidence" bias when predicting acquisition outcomes (Dunning, 2005), especially when evaluating a novel acquisition approach or procuring cutting edge technology. There are compelling yet conflicting research findings relating to whether this bias is driven by cognitive or motivational factors. This bias can be mitigated by implementing general debiasing techniques, such as red teaming (Reference more detailed discussion in the following paragraph), where participants are encouraged to view the decision from an adversarial or outsider's perspective. 3) There were 28 discrete instances where the "Hindsight" bias code was assigned, accounting for 8.1% of all of the biases identified during our analysis. The "Hindsight" bias is likely to be present in defense acquisition programs that exhibit a "this time, it's different" mindset, failing to incorporate or discounting the applicability of lessons learned from past programs. It is also likely that GAO and defense acquisition reformers are just as susceptible to this bias when judging decisions made with the benefit of hindsight. This is critical for acquisition reformers to mitigate because "decision makers

who expect to have their decisions scrutinized with hindsight are driven to bureaucratic solutions—and to an extreme reluctance to take risks" (Kahneman, 2011, p. 204). This observation is likely to strongly resonate with defense acquisition participants. The "Hindsight" bias can be mitigated by using general debiasing techniques. Additionally, defense acquisition reformers should seek to mitigate this bias when evaluating acquisition programs by emphasizing the complexities and uncertain context in which the examined decisions were made.

General debiasing and/or bias mitigation techniques and strategies are likely to yield positive results for a broad range of decision biases, regardless of whether the biases are cognitively and/or motivationally driven. Implementing general debiasing techniques would allow defense acquisition reform efforts to largely circumvent the formidable challenge of creating a synthesis between the HBP and GAO's incentives narrative. This approach can be characterized as treating the symptoms of a disease when the disease itself has no known cure or the diagnosis itself is uncertain. There is a wide and robust variety of general debiasing techniques, strategies, and tools already extensively utilized by the U.S. military, intelligence community, homeland security, local police, and private industry. For instance, "red teaming" is a structured approach to eliminate or mitigate cognitive biases and organizational assumptions/biases; and enable independent divergent critical thinking to see situations, problems, and potential solutions using alternative/ adversarial perspectives (Sandoz, 2001a; Sandoz, 2001b; U.S. Joint Chiefs of Staff, 2016; Zenko, 2015; Defense Science Board, 2003; Defense Science Board, 2010; UFMCS, 2016). Also, the U.S. Army's University of Foreign Military and Cultural Studies offers training, education, and practical applications/logical frameworks relating to "divergent processes, red teaming tools, and liberating structures, all aimed at decision support" (UFMCS, 2016, p. 1). Additionally, "liberating structures" are organizational rules, tools, and processes that enable people of different temperaments, personalities, status, and title to communicate and provide unbiased feedback equally without the fear of retribution (Torbert, 1991; Zenko, 2015; UFMCS, n.d.; LiberatingStructures.com, 2016). Liberating structures can include groupthink mitigation techniques, anonymous contribution methods, weighted anonymous feedback (UFMCS, 2014; Zenko, 2015). These tools have already

been created and implemented extensively. Accordingly, we recommend these techniques and strategies be incorporated into defense acquisition frameworks and processes. However, general debiasing techniques are not a cure-all for every decision bias. Some cognitive biases have a unique trigger, and thus, general debiasing techniques may have limited efficacy for these biases.

Our research revealed there is not a widely accepted taxonomy or authoritative dictionary of decision biases (Rodman, 2015, p. 18), which is why we had to compile a customized decision bias dictionary (DBD) to conduct our analysis. To further defense acquisition reform research efforts in this area, we recommend DOD establish an authoritative and standardized set of definitions/terminology relating to decision biases, decision bias taxonomy, and DBD. This will eliminate redundant efforts, and will enable and inform further research by establishing a common schema and consistent research approach. Our customized DBD, which largely incorporates Arnott's (1998, 2006) taxonomy, is a good starting point, especially considering a 2005 RAND study of modern decision science also largely incorporated Arnott's taxonomy (Davis et al., p. 13). However, we do not characterize it as sufficiently authoritative or comprehensive for widespread adoption across defense acquisition research efforts. Accordingly, we recommend a review of existing decision bias taxonomies be undertaken to inform and establish a customized decision bias taxonomy that includes both motivational and cognitive decision biases. While this taxonomy should be intuitive, it is imperative the included biases be well-established by scientifically robust and repeatable experimental evidence to the greatest extent practicable. Also, we recommend this taxonomy be simple, logical, and independent of any specific decision-making theoretical model. Once this taxonomy is established, a DBD with an intuitive/practical classification system, clear description/definitions, defense acquisition-specific examples and situational indicators, and associated terms/cognates should be created and published for use by defense acquisition researchers and practitioners. However, knowledge of decision biases does little to mitigate the influence of these biases (Kahneman, 2011, p. 417). Defense acquisition reformers that embrace the HBP perspective should be cautious not to implement training and awareness exercises as a means to mitigating cognitive biases.

Rather, a better understanding of the influence of decision biases can create the opportunity for defense acquisition reformers to design decision support systems and implement mitigation strategies that reduce the influence of these biases.

B. AREAS FOR FURTHER RESEARCH

In conjunction with our last conclusion/recommendation, we recommend further research into existing and/or novel decision bias taxonomies to inform and establish a standard customized decision bias taxonomy that includes both motivational and cognitive decision biases. We recommend these efforts leverage the broad and expanding knowledge base that exists across multiple fields of study. Also, since the study of decision biases, specifically cognitive biases, is growing so rapidly, we also recommend this taxonomy and any resulting DBD be updated regularly to incorporate new research and experimental findings. Because most research into decision biases has focused on cognitive rather than motivational biases (Montibeller & Winterfeldt, 2015), we recommend further research to better understand the influence that incentives/motivational factors exert over decision makers. This research should focus on creating robust and repeatable experimental evidence to identify and support the classification of motivational biases.

Second, we recommend further research be conducted to identify which decision biases most commonly and/or significantly influence improper deviations from sound acquisition practices. We recommend this review be conducted partly by seeking to detect the existence of decision biases using case studies and/ or real-world reviews/interviews across a broad range of acquisition programs. We would recommend an approach similar to our own methodology, but on a much greater scale to achieve broadly generalizable results. Additionally, in order to measure and/or determine the relative influence or impact of specific decision biases, we recommend further research be devised to gather evidence under controlled laboratory conditions. As stated in Chapter I, the inherent complexity of decision biases renders making such observations very difficult in the field, and necessitates controlled empirical/experimental research (Klein, 2008; as cited in Rodman, 2015). Finally, supplemental/focused research may be necessary to accurately assess the

existence/influence of certain decision biases that might be systematically underrepresented based on the method of study (i.e., the "Search" bias).

Third, our literature review found a lack of consensus regarding whether certain decision biases such as the "Desire," "Escalation," 'Overconfidence," and "Success" are cognitive and/or motivational. Accordingly, further study is recommended to ascertain whether these and other decision biases are likely to be purely cognitive-driven, purely incentive-driven, or some mixture of the two. A synthesis and greater understanding of how cognitive and motivational factors interact to drive behavior is central to creating a synthesis between the HBP and GAO's incentives narrative. Additionally, this area of research may be especially critical since some of these biases appeared very prevalently in our coded case studies. However, if such a synthesis of cognitive/motivational factors is not feasible, further study and application of general debiasing and/or bias mitigation techniques and strategies are likely to yield positive results, regardless of whether the biases are cognitively and/or motivationally driven.

Fourth, further study is recommended regarding the efficacy of utilizing specific mitigation and/or debiasing techniques to mitigate the influence of specific cognitive biases in defense acquisitions. This recommendation would be partly informed by our second and third recommendations for further research regarding which decision biases are most prevalent, and whether the biases are purely cognitive-driven, purely incentive-driven, or some mix between the two. However, our research has found that some cognitive biases have a unique trigger, and thus, the debiasing technique would require a specific mitigation technique. For instance, "Presentation" biases such as "Framing," "Linear," "Mode," "Order," and "Scale" cognitive biases are related to how information is presented or displayed to a decision maker. Further study of these biases could inform a set of information presentation best practices and/or requirements to systematically eliminate and/or mitigate poor decisions based on how data is presented. Such research is likely to yield best practices and recommendations that could be relatively easy to implement for numerous unique cognitive biases.

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APPENDIX. CODED TRANSCRIPT EXAMPLE—LCS CASE

United States Government Accountability Office

GAO

Testimony
Before the Committee on Armed Services, U.S. Senate

For Release on Delivery
Expected at 9:30 a.m. ET
Thursday, December 1, 2016

LITTORAL COMBAT SHIP AND FRIGATE

Congress Faced with Critical Acquisition Decisions

Statement of Paul L. Francis, Managing Director, Acquisition and Sourcing Management

GAO-17-262T

Summary of Comments on Coded Transcript_GAO-17-262T, Littoral Combat Ship and Frigate (ANALYSIS COPY).pdf

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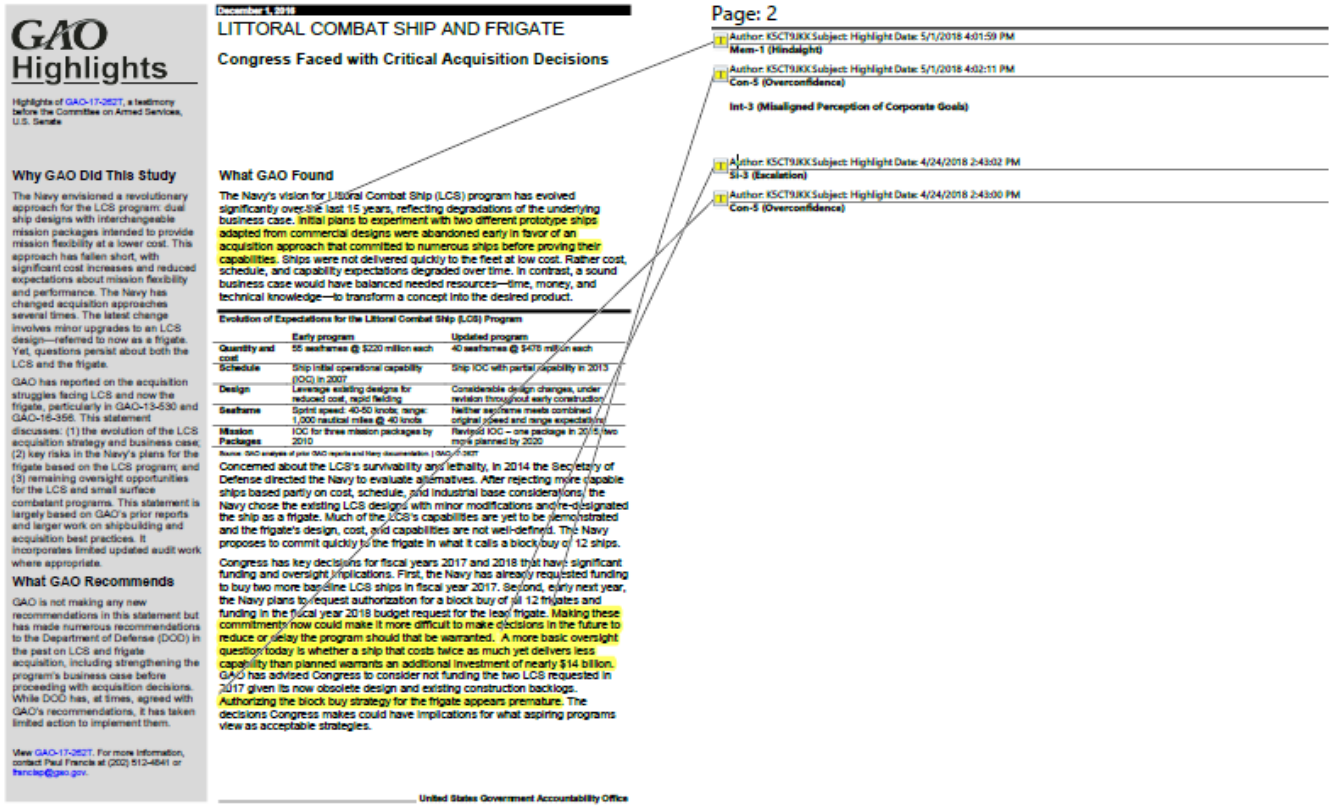

GAO Highlights

Highlights of GAO-17-2627, a testimony before the Committee on Armed Services, U.S. Senate

Why GAO Did This Study

The Navy envisioned a revolutionary approach for the LCS program: dual ship designs with interchangeable mission packages intended to provide mission flexibility at a lower cost. This approach has fallen short, with significant cost increases and reduced expectations about mission flexibility and performance. The Navy has changed acquisition approaches several times. The latest change involves minor upgrades to an LCS design—referred to now as a frigate. Yet, questions persist about both the LCS and the frigate.

GAO has reported on the acquisition struggles facing LCS and now the frigate, particularly in GAO-13-530 and GAO-16-356. This statement discusses: (1) the evolution of the LCS acquisition strategy and business case; (2) key risks in the Navy's plans for the frigate based on the LCS program; and (3) remaining oversight opportunities for the LCS and small surface combatant programs. This statement is largely based on GAO's prior reports and larger work on shipbuilding and acquisition best practices. It incorporates limited updated audit work where appropriate.

What GAO Recommends

GAO is not making any new recommendations in this statement but has made numerous recommendations to the Department of Defense (DOD) in the past on LCS and frigate acquisition, including strengthening the program's business case before proceeding with acquisition decisions. While DOD has, at times, agreed with GAO's recommendations, it has taken limited action to implement them.

View GAO-17-2627. For more information, contact Paul Francis at (202) 512-4841 or francisp@gao.gov.

December 6, 2016

LITTORAL COMBAT SHIP AND FRIGATE

Congress Faced with Critical Acquisition Decisions

What GAO Found

The Navy's vision for Littoral Combat Ship (LCS) program has evolved significantly over the last 15 years, reflecting degradations of the underlying business case. Initial plans to experiment with two different prototype ships adapted from commercial designs were abandoned early in favor of an acquisition approach that committed to numerous ships before proving their capabilities. Ships were not delivered quickly to the fleet at low cost. Rather cost, schedule, and capability expectations degraded over time. In contrast, a sound business case would have balanced needed resources—time, money, and technical knowledge—to transform a concept into the desired product.

Evolution of Expectations for the Littoral Combat Ship (LCS) Program

	Early program	Updated program
Quantity and cost	55 seaframes @ $220 million each	40 seaframes @ $476 million each
Schedule	Ship initial operational capability (IOC) in 2007	Ship IOC with partial capability in 2013
Design	Leverage existing designs for reduced cost, rapid fielding	Considerable design changes, under revision throughout early construction
Seaframe	Sprint speed: 40-50 knots; range: 1,000 nautical miles @ 40 knots	Neither seaframe meets combined original speed and range expectations
Mission Packages	IOC for three mission packages by 2010	Revised IOC – one package in 2015, two more planned by 2020

Source: GAO analysis of prior GAO reports and Navy documentation. | GAO-17-2627

Concerned about the LCS's survivability and lethality, in 2014 the Secretary of Defense directed the Navy to evaluate alternatives. After rejecting more capable ships based partly on cost, schedule, and industrial base considerations, the Navy chose the existing LCS designs with minor modifications and re-designated the ship as a frigate. Much of the LCS's capabilities are yet to be demonstrated and the frigate's design, cost, and capabilities are not well-defined. The Navy proposes to commit quickly to the frigate in what it calls a block buy of 12 ships.

Congress has key decisions for fiscal years 2017 and 2018 that have significant funding and oversight implications. First, the Navy has already requested funding to buy two more baseline LCS ships in fiscal year 2017. Second, early next year, the Navy plans to request authorization for a block buy of all 12 frigates and funding in the fiscal year 2018 budget request for the lead frigate. Making these commitments now could make it more difficult to make decisions in the future to reduce or delay the program should that be warranted. A more basic oversight question today is whether a ship that costs twice as much yet delivers less capability than planned warrants an additional investment of nearly $14 billion. GAO has advised Congress to consider not funding the two LCS requested in 2017 given its now obsolete design and existing construction backlogs. Authorizing the block buy strategy for the frigate appears premature. The decisions Congress makes could have implications for what aspiring programs view as acceptable strategies.

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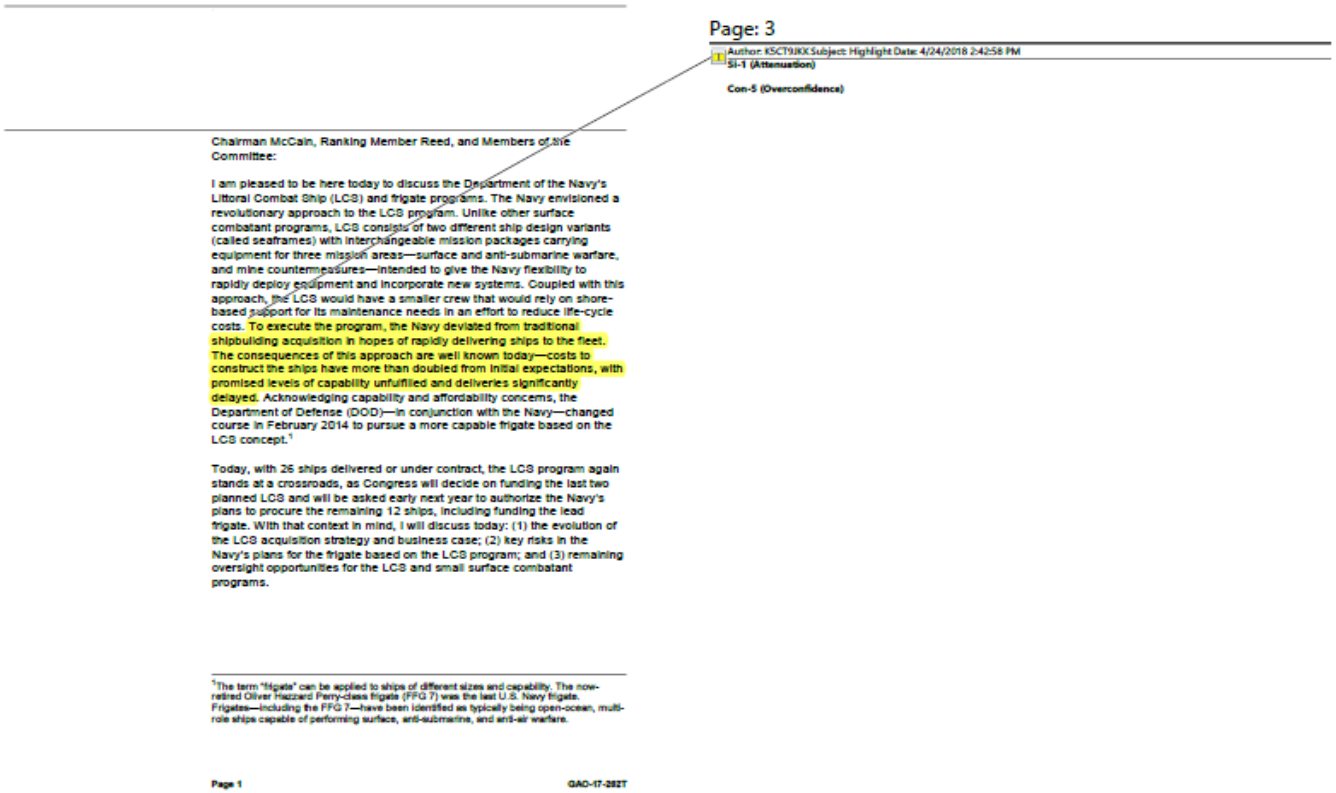
Author: K5CT9JKK Subject: Highlight Date: 5/1/2018 4:01:59 PM
Mem-1 (Hindsight)

Author: K5CT9JKK Subject: Highlight Date: 5/1/2018 4:02:11 PM
Con-5 (Overconfidence)

Int-3 (Misaligned Perception of Corporate Goals)

Author: K5CT9JKK Subject: Highlight Date: 4/24/2018 2:43:02 PM
SI-3 (Escalation)

Author: K5CT9JKK Subject: Highlight Date: 4/24/2018 2:43:00 PM
Con-5 (Overconfidence)



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Author: KSCT9JKX Subject: Highlight Date: 4/24/2018 2:42:58 PM
SI-1 (Attenuation)

Con-5 (Overconfidence)

Chairman McCain, Ranking Member Reed, and Members of the Committee:

I am pleased to be here today to discuss the Department of the Navy's Littoral Combat Ship (LCS) and frigate programs. The Navy envisioned a revolutionary approach to the LCS program. Unlike other surface combatant programs, LCS consists of two different ship design variants (called seaframes) with interchangeable mission packages carrying equipment for three mission areas—surface and anti-submarine warfare, and mine countermeasures—intended to give the Navy flexibility to rapidly deploy equipment and incorporate new systems. Coupled with this approach, the LCS would have a smaller crew that would rely on shore-based support for its maintenance needs in an effort to reduce life-cycle costs. To execute the program, the Navy deviated from traditional shipbuilding acquisition in hopes of rapidly delivering ships to the fleet. The consequences of this approach are well known today—costs to construct the ships have more than doubled from initial expectations, with promised levels of capability unfulfilled and deliveries significantly delayed. Acknowledging capability and affordability concerns, the Department of Defense (DOD)—in conjunction with the Navy—changed course in February 2014 to pursue a more capable frigate based on the LCS concept.[1]

Today, with 26 ships delivered or under contract, the LCS program again stands at a crossroads, as Congress will decide on funding the last two planned LCS and will be asked early next year to authorize the Navy's plans to procure the remaining 12 ships, including funding the lead frigate. With that context in mind, I will discuss today: (1) the evolution of the LCS acquisition strategy and business case; (2) key risks in the Navy's plans for the frigate based on the LCS program; and (3) remaining oversight opportunities for the LCS and small surface combatant programs.

[1]The term "frigate" can be applied to ships of different sizes and capability. The now-retired Oliver Hazzard Perry-class frigate (FFG 7) was the last U.S. Navy frigate. Frigates—including the FFG 7—have been identified as typically being open-ocean, multi-role ships capable of performing surface, anti-submarine, and anti-air warfare.

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SI-4 (Habit)

This testimony largely leverages our past reports on the LCS program from 2005 to 2016.[2] We also draw on some conclusions from our broader work on Navy shipbuilding and acquisition reform initiatives. More detailed information on our objectives, scope, and methodology for that work can be found in the issued reports. We conducted the work on which this statement is based in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. This statement also includes updates to information, as appropriate, based on program documentation and discussion with DOD officials—work that also was conducted in accordance with generally accepted government auditing standards.

The Course of the LCS Program Has Changed Significantly over Time

When first conceived, the LCS program represented an innovative approach for conducting naval operations, matched with a unique acquisition strategy that included two nontraditional shipbuilders and two different ships based on commercial designs—Lockheed Martin's Freedom variant and Austal USA's Independence variant, respectively.[3] The Navy planned to experiment with these ships to determine its preferred design variant. However, in relatively short order, this experimentation strategy was abandoned in favor of a more traditional acquisition of over 50 ships. More recently, the Secretary of Defense has questioned the appropriate capability and quantity of the LCS. The purpose of the program has evolved from concept experimentation, to LCS, and more recently, to an LCS that will be upgraded to a frigate. The strategy for contracting and competing for ship construction has also changed. This evolution is captured in figure 1.

[2]GAO, *Littoral Combat Ship: Need to Address Fundamental Weaknesses in LCS and Frigate Acquisition Strategies*, GAO-16-356, (Washington, D.C.: June 9, 2016); *Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost*, GAO-13-530, (Washington, D.C.: July 22, 2013); and *Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships*, GAO-05-255, (Washington, D.C.: Mar. 1, 2005).

[3]Lockheed Martin is the prime contractor for LCS 1 and the odd numbered seaframes. For LCS 2 and LCS 4, General Dynamics was the prime contractor for the Austal USA built ships. General Dynamics and Austal USA ended their teaming arrangement in 2010. Austal USA is the prime contractor for the remaining even-numbered seaframes.

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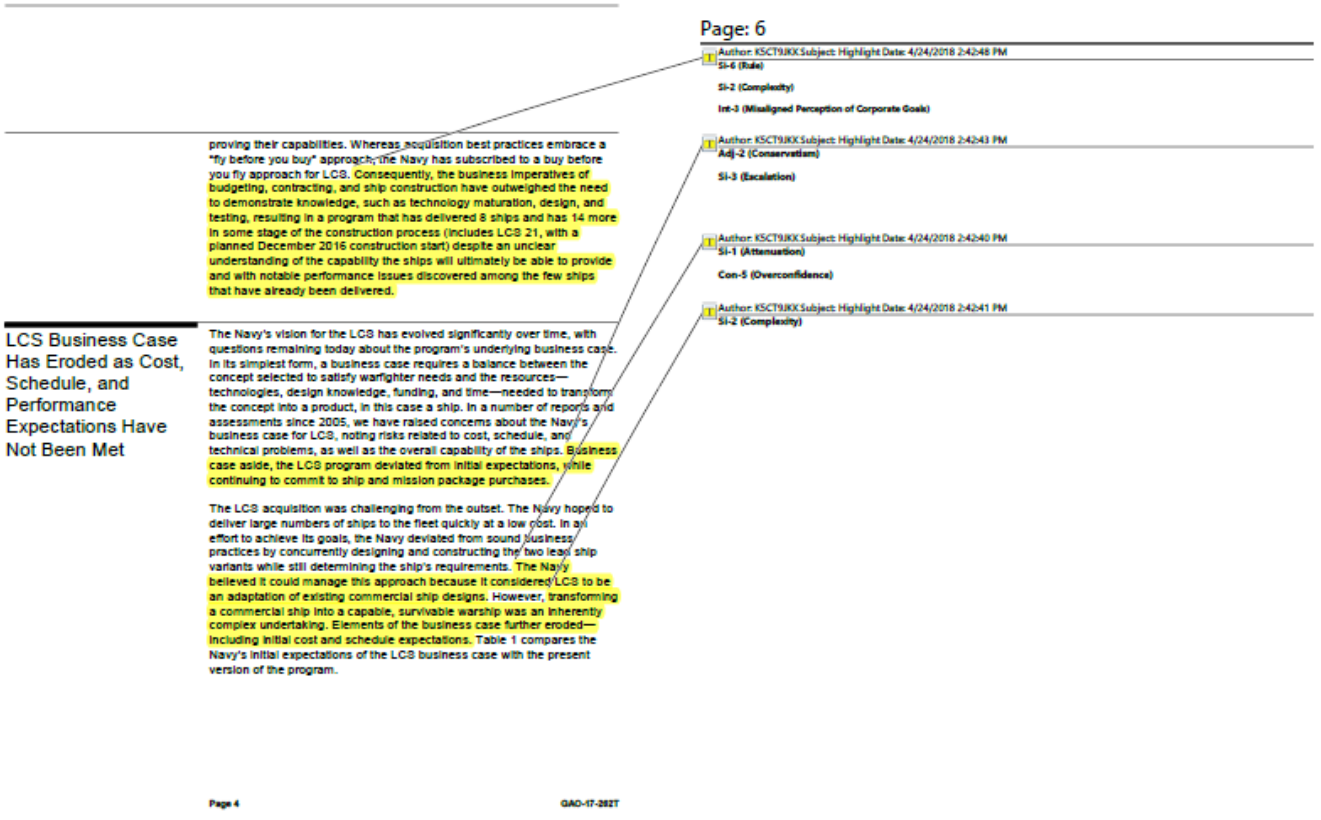
Con-5 (Overconfidence)

Figure 1: A Persistent Pattern of Change to the Littoral Combat Ship (LCS) Acquisition Strategy

Source: GAO analysis of Department of Defense data. | GAO-17-282T

While one could argue that a new concept should be expected to evolve over time, the LCS evolution has been complicated by the fact that major commitments have been made to build large numbers of ships before



proving their capabilities. Whereas acquisition best practices embrace a "fly before you buy" approach, the Navy has subscribed to a buy before you fly approach for LCS. Consequently, the business imperatives of budgeting, contracting, and ship construction have outweighed the need to demonstrate knowledge, such as technology maturation, design, and testing, resulting in a program that has delivered 8 ships and has 14 more in some stage of the construction process (includes LCS 21, with a planned December 2016 construction start) despite an unclear understanding of the capability the ships will ultimately be able to provide and with notable performance issues discovered among the few ships that have already been delivered.

LCS Business Case Has Eroded as Cost, Schedule, and Performance Expectations Have Not Been Met

The Navy's vision for the LCS has evolved significantly over time, with questions remaining today about the program's underlying business case. In its simplest form, a business case requires a balance between the concept selected to satisfy warfighter needs and the resources—technologies, design knowledge, funding, and time—needed to transform the concept into a product, in this case a ship. In a number of reports and assessments since 2005, we have raised concerns about the Navy's business case for LCS, noting risks related to cost, schedule, and technical problems, as well as the overall capability of the ships. Business case aside, the LCS program deviated from initial expectations, while continuing to commit to ship and mission package purchases.

The LCS acquisition was challenging from the outset. The Navy hoped to deliver large numbers of ships to the fleet quickly at a low cost. In an effort to achieve its goals, the Navy deviated from sound business practices by concurrently designing and constructing the two lead ship variants while still determining the ship's requirements. The Navy believed it could manage this approach because it considered LCS to be an adaptation of existing commercial ship designs. However, transforming a commercial ship into a capable, survivable warship was an inherently complex undertaking. Elements of the business case further eroded—including initial cost and schedule expectations. Table 1 compares the Navy's initial expectations of the LCS business case with the present version of the program.

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SI-6 (Rule)

SI-2 (Complexity)

Int-3 (Misaligned Perception of Corporate Goals)

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Adj-2 (Conservatism)

SI-3 (Escalation)

Author: KSCT9JKX Subject: Highlight Date: 4/24/2018 2:42:40 PM
SI-1 (Attenuation)

Con-5 (Overconfidence)

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SI-2 (Complexity)

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Table 1: Evolution of Expectations for the Navy's Littoral Combat Ship (LCS) Program

	Early program	Updated program
Quantity and cost	• 55 seaframes • $220 million per seaframe	• 40 seaframes (includes 12 frigates) • $478 million per seaframe
Schedule	• Ships rapidly fielded, with initial operational capability (IOC) in 2007, 3 years after program initiation	• IOC achieved with partial capability in 2013, 9 years after program initiation
Design	• Leverage existing designs to enable a low-cost, rapidly fielded platform	• Designs required considerable change and were under revision throughout the first several ships built
Seaframe Capability	• Sprint speed: 40-50 knots • Range: 4,300-nautical-mile range when operated at a speed of 18 knots and 1,000-nautical miles at 40 knots	• Speed: Freedom variant (odd-numbered ships, e.g., LCS 1) can meet speed requirements, but Independence variant (even-numbered ships, e.g., LCS 2) did not meet speed requirements; frigate will have reduced speed • Range: In 2009, endurance requirement reduced to 3,500-nautical-mile range at a speed of 14 knots. Freedom variant cannot meet these reduced requirements—with a 2,138-nautical miles range at a speed of 14 knots and 855 nautical miles at 43.6 knots; Independence variant can meet range requirements
Mission Packages Capability	• New capabilities would be rapidly fielded as the Navy would integrate existing technologies on to the three types of mission packages—mine countermeasures, surface warfare, and anti-submarine warfare	• Some technologies were ultimately less mature than envisioned, leading to significant difficulty developing mission capabilities • Only one of three packages (surface warfare) has demonstrated required performance. However, initial operational capability was achieved at a temporarily reduced minimum capability requirement
Crewing and Logistics Constructs	• LCS would be minimally manned (55-60 crew), with many support functions transferred to shore facilities • LCS was initially intended to have a 3-2-1 crewing construct, where 3 crews would support 2 LCS, and 1 LCS would remain forward deployed	• Crew size has increased over time to 70 • The Navy is transitioning to a blue/gold crew concept for LCS, where two crews will rotate on and off the same hull

Source: GAO analysis of prior GAO reports and Navy documentation. | GAO-17-262T

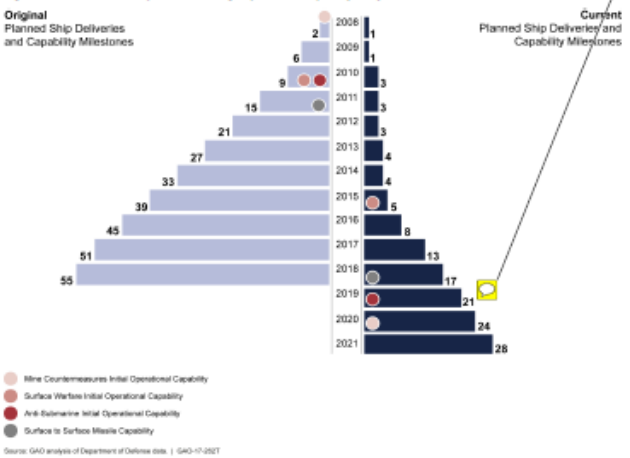
Note: Costs are in fiscal year 2005 dollars.

Our recent work has shown that the LCS business case continues to weaken. LCS ships under construction have exceeded contract cost targets, with the government responsible for paying for a portion of the cost growth. This growth has prompted the Navy to request $246 million in additional funding for fiscal years 2015-2017 largely to address cost overruns on 12 LCS seaframes. Similarly, deliveries of almost all LCS under contract (LCS 5-26) have been delayed by several months, and, in some cases, closer to a year or longer. Navy officials recently reported that, despite having had 5 years of LCS construction to help stabilize ship delivery expectations, the program would not deliver four LCS in fiscal year 2016 as planned. Whereas the program expected to deliver all 55

ships in the class by fiscal year 2018, today that expectation has been reduced to 17 ships.

LCS mission packages, in particular, lag behind expectations. The Navy has fallen short of demonstrating that the LCS with its mission packages can meet the minimum level of capability defined at the beginning of the program. As figure 2 shows, 24 LCS seaframes will be delivered by the time all three mission packages achieve a minimum capability.

Figure 2: Littoral Combat Ship Mission Package Operational Capability Delays Since 2007



Source: GAO analysis of Department of Defense data. | GAO-17-252T

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Adj-4 (Regression)

Stat-1 (Base Rate)

Stat-3 (Conjunction)

Since 2007, delivery of the total initial mission package operational capability has been delayed by about 9 years (from 2011 to 2020) and the Navy has lowered the level of performance needed to achieve the initial capability for two packages—surface warfare and mine countermeasures. In addition to mission package failures, the Navy has not met several seaframe objectives, including speed and range. For example, Navy testers estimate that the range of one LCS variant is about half of the minimum level identified at the beginning of the program. As the Navy continues to concurrently deliver seaframes and develop mission packages, it has become clear that the seaframes and mission package technologies were not mature and remain largely unproven. In response, the Navy recently designated the first four LCS as test ships to support an aggressive testing schedule between fiscal years 2017 and 2022. Additional deficiencies discovered during these tests could further delay capability and require expensive changes to the seaframes and mission packages that have already been delivered.

As the cost and schedule side of the business case for LCS has grown, performance and capabilities have declined. Changes in the LCS concept of operations are largely the consequence of less than expected lethality and survivability, which remain mostly unproven 7 years after delivery of the lead ships. LCS was designed with reduced requirements as compared to other surface combatants, and over time the Navy has lowered several survivability and lethality requirements further and removed some design features—making the ships less survivable in their expected threat environments and less lethal than initially planned. This has forced the Navy to redefine how it plans to operate the ships. Our previous work highlighted the changes in the LCS's expected capability, as shown in table 2.

Table 2: Evolution of Littoral Combat Ship (LCS) Capability

Concept	Initial	Current
LCS's capability against adversaries	LCS was primarily planned to be used in major combat operations, enter contested spaces, and be employable and sustainable throughout the battlespace regardless of anti-access or area denial environments.	The Navy acknowledges current LCS weapon systems are under-performing and offer little chance of survival in a combat scenario. LCS lacks the ability to operate independently in combat and should not be employed outside a benign, low-threat environment unless escorted by a multi-mission combatant providing credible anti-air, anti-surface, and anti-submarine protection.
How LCS will deploy	LCS will be a self-sufficient combatant designed to fight and win in shallow water and near-land environments without risking larger combatants in constricted areas.	LCS's dependencies in combat require it to be well-protected by multi-mission combatants. Multiple LCS will likely have to operate in a coordinated strike attack group fashion for mutual support.

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SI-3 (Escalation):

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Con-2 (Confirmation)

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Pres-1 (Framing):

Concept	Initial	Current
How mission packages swaps will be utilized	Mission packages will be quickly swapped out in an expeditionary theater in a matter of days.	Mission packages can be swapped within 72 hours only if all the equipment and personnel are in theater. An LCS executing a package swap could be unavailable for between 12-29 days. The Navy now expects mission package swaps will be more infrequent than initially envisioned.

Source: GAO analysis of Navy documentation. | GAO-17-282T

Further capability changes may be necessary as the Navy continues to test the seaframes and mission packages, as well as gain greater operational experience. For example, the Navy has not yet demonstrated that LCS will achieve its survivability requirements and does not plan to complete survivability assessments until 2018—after more than 24 ships are either in the fleet or under construction. The Navy has identified unknowns related to the Independence variant's aluminum hull, and conducted underwater explosion testing in 2016 but the Navy has yet to compile and report the results. Both variants also sustained some damage in trials in rough sea conditions, but the Navy has not completed its analytical report of these events. Results from air defense and cybersecurity testing also indicate capability concerns.

Business Case for Frigate Program Remains Uncertain

The Navy elected to pursue a frigate concept based on a minor modified LCS. The frigate, as planned, will provide multi-mission capability that is an improvement over LCS and offers modest improvements to some other capabilities, such as the air search radar. Still, many questions remain to be settled about the frigate's design, cost, schedule, and capabilities—all while the Navy continues to purchase additional LCS. Despite the uncertainties, the Navy's acquisition strategy involves effectively demonstrating a commitment to buy all of the planned frigates—12 in total—before establishing realistic cost, schedule, and technical parameters—because the Navy will ask Congress to authorize the contracting approach for the 12 frigates (what the Navy calls a block buy contract) in 2017.[8] Further, the frigate will inherit many of the

[8]The Navy plans to request authorization in 2017 to use what it calls a block buy contract to purchase the frigate—the same contracting approach used for LCS—and funding in the fiscal year 2018 budget request for the lead frigate. Our past analysis of the LCS contracts found that a block buy approach could affect Congress's funding flexibility. For example, the LCS block buy contracts provide that a failure to fully fund a purchase in a given year would make the contract subject to renegotiation, which could result in the government paying more for ships. If similar terms are included in the frigate contract, the same potential effect may apply.

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SI-1 (Attenuation)

SI-2 (Complexity)

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SI-1 (Attenuation)

Con-5 (Overconfidence)

Int-3 (Misaligned Perception of Corporate Goals)

Mem-1 (Hindsight)

Stat-3 (Conjunction)

shortcomings or uncertainties of the LCS, and does not address all the priorities that the Navy had identified for its future frigate.

Frigate Cost Uncertainty and a Compressed Schedule Contribute to Gaps in Program Knowledge

The costs for the frigate are still uncertain. Navy officials have stated that the frigate is expected to cost no more than 20 percent—approximately $100 million—more per ship than the average LCS seaframes. However, the Navy will not establish its cost estimate until May 2017— presumably after the Navy requests authorization from Congress in its fiscal year 2018 budget request for the block buy contracting approach for 12 frigates—raising the likelihood that the budget request will not reflect the most current costs for the program moving forward.

In addition to the continued cost uncertainty, the schedule and approach for the frigate acquisition have undergone substantial changes in the last year, as shown in table 3.

Table 3: Changes in Frigate Acquisition Plan

Previous plan (December 2015)	Current plan (October 2016)
Dual contract award in fiscal year 2019	Downselect award to one shipbuilder in summer 2018
20 frigates (10 per shipbuilder)	12 frigates
Government-led, prescribed design	Contractor-driven design process based on build specifications; increased government furnished equipment
Multiple frigate upgrade packages, with a fiscal year 2019 bid to mature frigate design	Single frigate upgrade package expected from each contractor in fiscal year 2018
Detail design in fiscal year 2018 to increase design knowledge prior to contract award	Detail design begins after downselect award in 2018

Source: GAO analysis of Navy documentation. | GAO-17-292T

According to frigate program officials, under the current acquisition approach the Navy will award contracts in fiscal year 2017 to each of the current LCS contractors to construct one LCS with a block buy option for 12 additional LCS—not frigates. Then, the Navy plans to obtain proposals from both LCS contractors in late 2017 that would upgrade the block buy option of LCS to frigates using frigate-specific design changes and modifications. The Navy will evaluate the frigate upgrade packages and then exercise the option—now for frigates—on the contract that provides the best value based on tradeoffs between price and technical factors. This downselect will occur in summer 2018. Figure 3 illustrates how the Navy plans to modify the fiscal year 2017 LCS contract to convert the ships in the block buy options to frigates.

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Adj-4 (Regression)

Con-5 (Overconfidence)

Si-1 (Attenuation)

Int-3 (Misaligned Perception of Corporate Goals)

Int-4 (Strategic Misrepresentation)

Stat-3 (Conjunction)

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Adj-1 (Anchoring and adjustment)

Adj-4 (Regression)

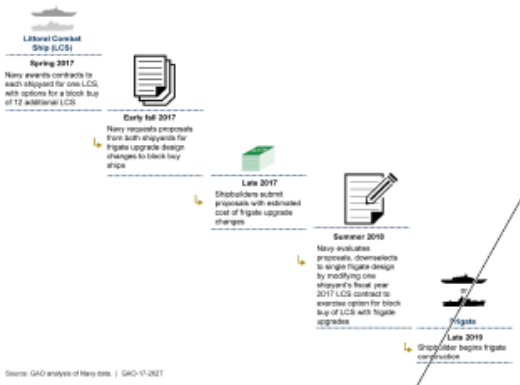
Con-5 (Overconfidence)

SI-1 (Attenuation)

Mem-1 (Hindsight)

SI-4 (Habit)

Figure 3: Navy Block Buy Option Contract Modification Process for Frigate Procurement



Source: GAO analysis of Navy data. | GAO-17-292T

The Navy's current plan, which moves the frigate award forward from fiscal year 2019 to fiscal year 2018, is an acceleration that continues a pattern of committing to buy ships in advance of adequate knowledge. Specifically, the Navy has planned for its downselect award of the frigate to occur before detail design of the ship begins. As we previously reported, awarding a contract before detail design is completed—though common in Navy ship acquisitions—has resulted in increased ship prices.[5] Further, in the absence of a year of frigate detail design, the

[5] GAO-16-356 and GAO, *Defense Acquisitions: Improved Management Practices Could Help Minimize Cost Growth in Navy Shipbuilding Programs*, GAO-05-183 (Washington, D.C.: Feb. 28, 2005).

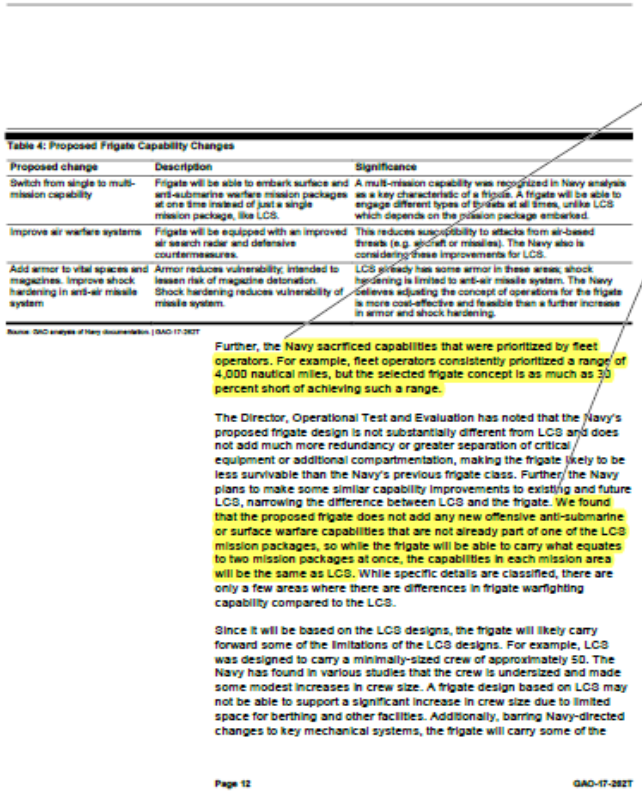


Table 4: Proposed Frigate Capability Changes

Proposed change	Description	Significance
Switch from single to multi-mission capability	Frigate will be able to embark surface and anti-submarine warfare mission packages at one time instead of just a single mission package, like LCS.	A multi-mission capability was recognized in Navy analysis as a key characteristic of a frigate. A frigate will be able to engage different types of threats at all times, unlike LCS which depends on the mission package embarked.
Improve air warfare systems	Frigate will be equipped with an improved air search radar and defensive countermeasures.	This reduces susceptibility to attacks from air-based threats (e.g. aircraft or missiles). The Navy also is considering these improvements for LCS.
Add armor to vital spaces and magazines. Improve shock hardening in anti-air missile system	Armor reduces vulnerability, intended to lessen risk of magazine detonation. Shock hardening reduces vulnerability of missile system.	LCS already has some armor in these areas; shock hardening is limited to anti-air missile system. The Navy believes adjusting the concept of operations for the frigate is more cost-effective and feasible than a further increase in armor and shock hardening.

Source: GAO analysis of Navy documentation. | GAO-17-282T

Further, the Navy sacrificed capabilities that were prioritized by fleet operators. For example, fleet operators consistently prioritized a range of 4,000 nautical miles, but the selected frigate concept is as much as 30 percent short of achieving such a range.

The Director, Operational Test and Evaluation has noted that the Navy's proposed frigate design is not substantially different from LCS and does not add much more redundancy or greater separation of critical equipment or additional compartmentation, making the frigate likely to be less survivable than the Navy's previous frigate class. Further, the Navy plans to make some similar capability improvements to existing and future LCS, narrowing the difference between LCS and the frigate. We found that the proposed frigate does not add any new offensive anti-submarine or surface warfare capabilities that are not already part of one of the LCS mission packages, so while the frigate will be able to carry what equates to two mission packages at once, the capabilities in each mission area will be the same as LCS. While specific details are classified, there are only a few areas where there are differences in frigate warfighting capability compared to the LCS.

Since it will be based on the LCS designs, the frigate will likely carry forward some of the limitations of the LCS designs. For example, LCS was designed to carry a minimally-sized crew of approximately 50. The Navy has found in various studies that the crew is undersized and made some modest increases in crew size. A frigate design based on LCS may not be able to support a significant increase in crew size due to limited space for berthing and other facilities. Additionally, barring Navy-directed changes to key mechanical systems, the frigate will carry some of the

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Con-7 (Selectivity)

SI-6 (Rule)

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Adj.-1 (Anchoring and adjustment)

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Con-2 (Confirmation)

Si-1 (Attenuation)

more failure-prone LCS equipment, such as some propulsion equipment, and will likely carry some of the non-fleet-standard, LCS-unique equipment that has challenged the Navy's support and logistics chain. Uncertainties or needs that remain with the surface and anti-submarine warfare mission packages, such as demonstrating operational performance of the surface-to-surface missile and the anti-submarine warfare package, also pose risk for the frigate.

Limited Opportunities Remain to Shape LCS and Frigate Programs

The Navy's plans for fiscal years 2017 and 2018 involve significant decisions for the LCS and the frigate programs, including potential future commitments of approximately $14 billion for seaframes and mission packages. First, the Navy plans to buy the last two LCS in fiscal year 2017, even though DOD and the Navy recognize that the LCS does not meet needs. Second, the Navy is planning to seek congressional authorization for a block buy of all planned frigates and funding for the lead frigate as soon as next year—2017—despite significant unknowns about the cost, schedule, and capability of the vessel. The Navy's acquisition approach for the frigate raises concerns about overcommitting to the future acquisition of ships for which significant cost, schedule, and technical uncertainty remains. Similar to what we previously have advised about LCS block buy contracting, a frigate block buy approach could reduce funding flexibility. For example, the LCS contracts provide that a failure to fully fund the purchase of a ship in a given year would make the contract subject to renegotiation. Following this reasoning, such a failure to fund a ship in a given year could result in the government paying more for remaining ships under the contract, which provides a notable disincentive to take any action that might delay procurement, even when a program is underperforming.

The Navy requested funding for two LCS in its fiscal year 2017 budget request. We previously suggested that Congress consider not funding any requested LCS in fiscal year 2017 because of unresolved concerns with lethality and survivability of the LCS design, the Navy's ability to make needed improvements, and the lagging construction schedule of the shipyards. As figure 4 depicts, even if no ships were funded in fiscal year 2017, delays that have occurred for previously funded ships have resulted in a construction workload that extends into fiscal year 2020.

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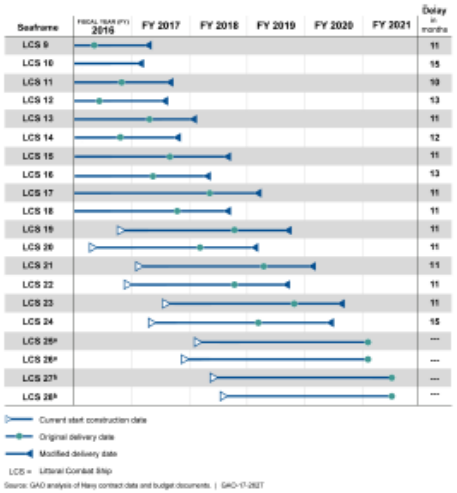
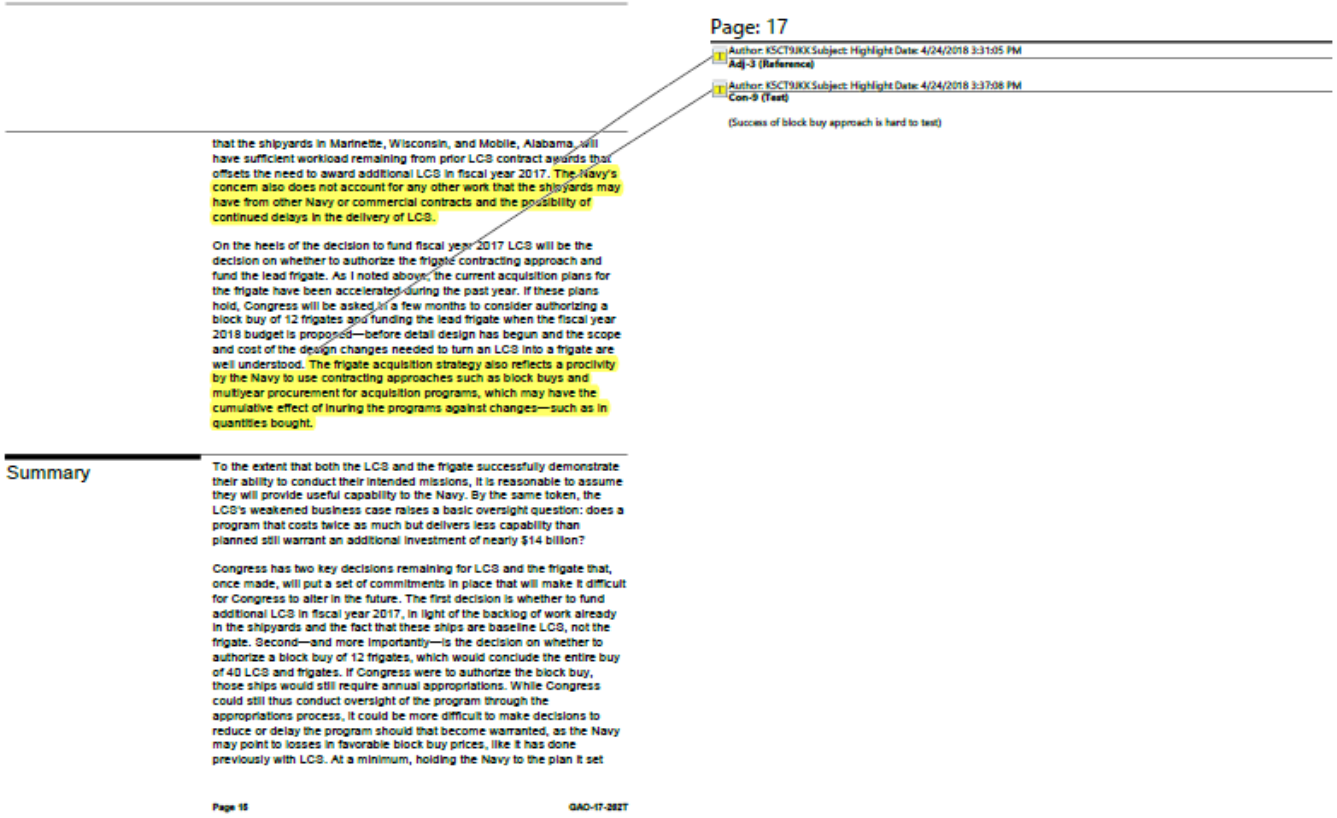
Figure 4: Construction Demands for Littoral Combat Ship (LCS) Shipyards



Source: GAO analysis of Navy contract data and budget documents. | GAO-17-262T

[a]The delivery dates for LCS 25 and 26—awarded in March 2016—have not been modified.
[b]The Navy has not awarded contracts for construction of LCS 27 or 28.

In all, 8 ships have been delivered (LCS 1-8) and 14 are in various phases of construction (LCS 9-22), with 3 more (LCS 23, 24, and 26) set to begin construction later in fiscal year 2017. Although the Navy has argued that pausing LCS production would result in loss of production work and start-up delays to the frigate program, the schedule suggests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(Success of block buy approach is hard to test)
that the shipyards in Marinette, Wisconsin, and Mobile, Alabama, will have sufficient workload remaining from prior LCS contract awards that offsets the need to award additional LCS in fiscal year 2017. The Navy's concern also does not account for any other work that the shipyards may have from other Navy or commercial contracts and the possibility of continued delays in the delivery of LCS.
On the heels of the decision to fund fiscal year 2017 LCS will be the decision on whether to authorize the frigate contracting approach and fund the lead frigate. As I noted above, the current acquisition plans for the frigate have been accelerated during the past year. If these plans hold, Congress will be asked in a few months to consider authorizing a block buy of 12 frigates and funding the lead frigate when the fiscal year 2018 budget is proposed—before detail design has begun and the scope and cost of the design changes needed to turn an LCS into a frigate are well understood. The frigate acquisition strategy also reflects a proclivity by the Navy to use contracting approaches such as block buys and multiyear procurement for acquisition programs, which may have the cumulative effect of inuring the programs against changes—such as in quantities bought.
Summary
To the extent that both the LCS and the frigate successfully demonstrate their ability to conduct their intended missions, it is reasonable to assume they will provide useful capability to the Navy. By the same token, the LCS's weakened business case raises a basic oversight question: does a program that costs twice as much but delivers less capability than planned still warrant an additional investment of nearly $14 billion?
Congress has two key decisions remaining for LCS and the frigate that, once made, will put a set of commitments in place that will make it difficult for Congress to alter in the future. The first decision is whether to fund additional LCS in fiscal year 2017, in light of the backlog of work already in the shipyards and the fact that these ships are baseline LCS, not the frigate. Second—and more importantly—is the decision on whether to authorize a block buy of 12 frigates, which would conclude the entire buy of 40 LCS and frigates. If Congress were to authorize the block buy, those ships would still require annual appropriations. While Congress could still thus conduct oversight of the program through the appropriations process, it could be more difficult to make decisions to reduce or delay the program should that become warranted, as the Navy may point to losses in favorable block buy prices, like it has done previously with LCS. At a minimum, holding the Navy to the plan it set
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forth in the fiscal year 2017 budget submission, which provided for detail design activities in advance of a contract award in fiscal year 2019, affords more time to reduce LCS uncertainties that directly affect the frigate and to build design knowledge to reduce technical and cost risks. Additionally, forgoing a frigate award in fiscal year 2018 offers the Navy an opportunity to better demonstrate to Congress whether the frigate's estimated cost and expected capabilities warrant the additional investment.

GAO has reported extensively about what we refer to as the defense acquisition culture, a prevailing set of incentives that encourages decisions to go forward with programs before they are ready and a willingness to accept cost growth and schedule delays as the likely byproduct of such decisions. This Committee has been particularly concerned with repeated acquisition problems and has actively advocated for legislative solutions. As I testified last year on the Ford-class Aircraft Carrier, Congress has a very important role to play in shaping the acquisition culture, particularly in what it sanctions via funding approvals. If programs that propose optimistic or rushed acquisition strategies win funding approval, those strategies are, in effect, sanctioned. The upcoming decisions on the LCS and the frigate represent opportunities for Congress to take a stand on what it is willing to fund and what that means for maintaining—or changing—the defense acquisition culture.

Chairman McCain, Ranking Member Reed, and Members of the Committee, this completes my prepared statement. I would be pleased to respond to any questions that you may have at this time.

GAO Contact and Staff Acknowledgments

If you or your staff has any questions about this statement, please contact Paul L. Francis at (202) 512-4841 or francisp@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. GAO staff who made key contributions to this testimony are Michele Mackin (Director), Diana Moldafsky (Assistant Director), Pete Anderson, Jacob Leon Beier, Laurier Fish, Kristine Hassinger, C. James Madar, Sean Merrill, LeAnna Parkey, and Robin Wilson.

Related GAO Products

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